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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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See Advertisement, Jan. 14, page 53.

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See Full Page Advt. page 52, Jan. 14.

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See Advertisement page 30, Jan. 21. 2402

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See half-page Advertisement page 62, Jan. 28.

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For the Prevention of Steam Boiler Explosions and for the Attainment of Economy in the Application of Steam.
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Founded 1854 by Sir W. Fairbairn.
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Patents and Designs Act, 1907.

Notice is Hereby Given that

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Particulars of the proposed Amendment were set forth in the *Illustrated Official Journal (Patents)*, issued on the 2nd February, 1916.
Any person or persons may give notice of opposition to the Amendment by leaving Patents Form No. 15, at the Patent Office, 25, Southampton Buildings, London, W.C., within one calendar month from the date of the said Journal.
W. Temple Franks,
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TENDERS.

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Tenders for the Supply

of:—
Steel Tyres (900), for Carriages and Wagons.
Specification and Form of Tender may be obtained at the Company's Offices.
Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Ltd., marked "Tender for Steel Tyres," must be left at the Offices of the Company not later than One o'clock, on Wednesday, the 23rd February, 1916.
The Company is not bound to accept the lowest or any Tender.
A charge, which will not be returned, will be made of 20s. for each copy of the Specification.
Copies of the Drawings may be obtained, on payment, at the Office of Robert White, Esq., M.Inst.C.E., Consulting Engineer to the Company, 3, Victoria Street, S.W.
91, York Street, Westminster, S.W.
1st February, 1916. D 511

County of London.

The London County Council invites

Tenders for the Supply of

(I) 6000 Forged Steel DRIVING WHEEL TYRES, and 4000 Forged Steel TRAILING WHEEL TYRES, during twelve calendar months from the date of acceptance; or (II) alternatively, 3000 Forged Steel DRIVING WHEEL TYRES, and 2000 Forged Steel TRAILING WHEEL TYRES, for six calendar months from the date of acceptance.
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The person whose Tender is accepted will be bound by the Contract to pay wages at rates not less, and to observe hours of labour not greater, than the rates and hours set out in the Council's list. Particulars of the Council's Standing Orders as to its Conditions of Tender and Contract are given in every issue of the *London County Council Gazette*. No Tender received at the County Hall, after Eleven a.m., on Tuesday, 29th February, 1916, will be considered. The Council does not bind itself to accept any Tender.
James Bird,
Clerk of the London County Council.
County Hall, Spring Gardens, S.W.
31st January, 1916. D 493

County Borough of Belfast.

Works Department.

Tenders for Stores, Work, and Uniform Clothing.

The Works Committee are prepared to receive

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Glasing.	
Mill Furnishings.	

Forms of Tender and particulars may be obtained from Mr. Hector F. Gullan, M. Inst. C.E., Superintendent of Works, City Hall.
Sealed Tenders, on Official Forms only, endorsed "Tender for....., Works Department," to be lodged in my Office before Twelve o'clock Noon on 15th February, 1916.
The lowest or any Tender will not necessarily be accepted. The whole or any part of a Tender may be accepted.
A Tender, if sent by post, must be registered; if delivered by hand an official receipt must be obtained for it, otherwise the undersigned will not be responsible. D 522
R. Meyer, Town Clerk.

The Great Indian Peninsula Railway Company.
The Directors are prepared to receive

Tenders for the Supply of

the following STORES, namely:—
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India-Rubber Sheets, &c.
Stationery, &c.
Bolts, Nuts and Rivets.
Wrought Iron, Grade "B."
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Specifications and Forms of Tender may be obtained at this Office on payment of the fee for the Specification, which payment will not be returned.
Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Water Cranes," or as the case may be, not later than Eleven o'clock a.m., on Thursday, the 10th February, 1916.
The Directors do not bind themselves to accept the lowest or any Tender.
R. H. Walpole,
Company's Offices, Secretary.
48, Copthall Avenue, London, E.C.
2nd February, 1916. D 528

APPOINTMENTS OPEN.

Wanted, Thoroughly Experienced

and Capable ENGINEER, for War work. One with some mechanical experience preferred. Competence in constructional detail essential. Give references, state age and salary required. No person already employed on Government work will be engaged.—Apply, nearest LABOUR EXCHANGE, mentioning this Journal, and D 391.

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THE AUTOGENOUS WELDING OF BOILER-PLATES.

AN interesting report* has been issued by the Swiss Society of Steam-Boiler Owners, giving particulars of a number of tests carried out by Mr. E. Höhn, chief engineer of the Society, on various welds made on a steel plate. Fourteen Swiss firms took part in the tests, one of these firms effecting the welds by the use of the electric current, while twelve used the oxy-acetylene blow-pipe, and one water-gas. Each firm was given an open-hearth mild-steel plate, of one and the same cast, manufactured by the Thyssen Steel Works. The plate measured 1100 mm. by 1100 mm. by 12 mm. (43.30 in. square by 0.472 in.). From the centre of this was cut a second plate, measuring 400 mm. by 400 mm. by 12 mm. (15.75 in. square by 0.472 in.), which had to be welded in, the other operations consisting in the welding on of an oval boss, 120 mm. by 80 mm. (4.724 in. by 3.150 in.), of a short tubular piece, 102 mm. (4 in.) in diameter, inserted in a hole cut through the plate thickness, and in welding up artificial cracks made in the plate by means of a saw and a punching-tool. The plates, after treatment at the respective works, were returned to the Federal Laboratory for the Testing of Materials, Zurich, where a number of tests were carried out, including tensile tests, cold and hot bending tests, drift and punching tests, impact tests on notched bars, and the attack by acid of the welded parts. The whole of the plates were similarly tested with the greatest care. The plate showing the welds and the location of the test-pieces is illustrated in Fig. 1. The references are as follow :—

A—Mild-steel plate, 1100 mm. by 1100 mm. by 12 mm.
B—Mild-steel plate, 400 mm. by 400 mm. by 12 mm.; welded on both faces.
C—Sawn length; welded on one face.
D—" " welded on both faces.
E—Cracks made between four holes; *a* and *b* welded on one face, and *c* and *d* on both faces.
F—Boss, welded directly on plate A.
G—Short tube-length, welded in the direction of the arrow.

The table briefly describing the process of welding as carried out at the different works shows very great variations under the different headings. The work was exactly the same in all instances, but one firm took 45 hours, including the time for cooling, annealing, and straightening, and used 21,000 litres (741 cub. ft.) of oxygen, and 18,000 litres (635 cub. ft.) of dissolved acetylene; another used about the same amount of both gases, but took 12 hours, presumably for the welding operations considered alone; whilst of two other firms, one used 5520 litres (195 cub. ft.) of oxygen, 4800 litres (169 cub. ft.) of acetylene, and took 13 hours; the other used 5125 litres (181 cub. ft.) of oxygen, 2800 litres (98 cub. ft.) of acetylene styled "Zinser," and took 5½ hours. The plates as received from the different firms showed a great difference in their outside appearance; some were clean and smooth, whilst others were rough and dented.

The test-pieces were all taken from the central portion of the plate, and half the length of each test-piece included a portion of the second smaller plate welded in at the centre of the larger one. The test-pieces for tensile and bending tests were machined on their sides only, and the results of the tests (tensile strength, apparent limit of elasticity, &c.) refer to the portion outside the weld. This was the only means of obtaining a common basis for comparison, for in the tensile tests fracture occurred either at the weld or outside it, and all the test-pieces were not of uniform thickness at the welded portion; the increase in thickness in the case of the plate electrically treated was approximately double, whilst being generally low in the case of those having autogenous welds. Elongation was measured on lengths of 20 cm. (7⅞ in.), and also on 5-cm. (2-in.) lengths, outside the fractured portion and outside the weld. By this means the greater elongation at the fracture zone, which was unreliable when it coincided with the weld, did not affect the results, and the figures given for elongation allow of a safe comparison.

The fourteen welded plates and one untreated plate, kept in reserve for comparison purposes, yielded sixty test-pieces for tensile tests, fifty-two of which were from plates having autogenous welds. The test-pieces measured 3 cm. by 1.2 cm. ($1\frac{3}{16}$ in. by $\frac{7}{16}$ in.), and 200 mm. ($7\frac{7}{8}$ in.) in length between gauge-points. Of these fifty-two test-pieces for tensile tests, twenty-seven, or 52 per cent., broke outside the weld, and twenty-five, or 48 per cent., at the weld itself. Of the four derived from the plate electrically welded, three broke outside the weld, and one at the weld. The direction of rolling was unknown, and could not be taken into consideration. The following are the average results obtained in the case of the fifty-two test-pieces proceeding from the autogenous-welded plates, expressed as percentages of the figures for the untreated plate taken as 100 :—

	Per Cent.
Apparent limit of elasticity	87
Tensile strength	82
Reduction of area...	71
Elongation on fracture on 20 cm. ...	58
" 5 cm. outside fracture and weld...	53
Coefficient of quality (after Tetmayer)*	50

The average figures for the twenty-seven test-pieces which broke outside the weld, and for the twenty-five which broke at the weld itself, are

Fig. 1.

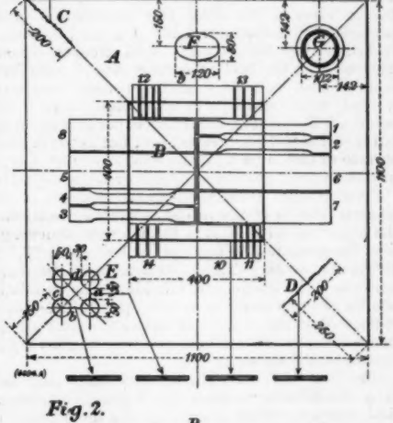


Fig. 2.

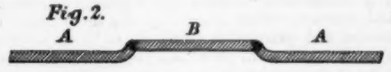


Fig. 3.

interesting as a further comparison. They are given in the following table :—

—	Average of 4 Tests on Untreated Plate.		Average of Tests on 27 Test-Pieces (Outside Weld).		Average of Tests on 25 Test-Pieces (at the Weld.)	
Apparent limit of elasticity .. ..t/cm.²	2.66	100	2.35	88	2.25	84
(tons per sq. in.)	16.89	—	14.92	—	14.29	—
Tensile strength ..t/cm.²	3.87	100	3.36	87	2.96	76
(tons per sq. in.)	24.57	—	21.33	—	18.79	—
Reduction of area per cent.	50.10	100	62.30	104	21.88	36
Elongation in 20 cm. "	27.60	100	22.10	80	9.42	34
" 20 cm., outside fracture per cent.	20.00	100	13.20	66	7.76	39
Coefficient of quality ..	1.07	100	0.76	70	0.30	28

As will be seen from the above, the test-pieces which broke at the weld had an average tensile strength of 76 per cent. only, and an elongation outside the fracture of 39 per cent., whilst the averages of those which broke outside the weld are respectively 87 and 66 per cent. Both classes of test-pieces show a marked decrease in strength.

In considering the tensile strength, the fact should not be lost sight of that the welded plates were annealed, a process which generally tends to decrease the tensile strength, whilst increasing the elongation. As will be seen, the average of the fifty-two tests show the tensile strength to have fallen to 82 per cent., and annealing has contributed to this result; an increase in elongation should, on the other hand, have occurred, but this was not the case; it fell to 53 per cent., which indicates that the quality of the metal was injured by the welding operations. This is also evidenced by the coefficient of quality, which fell to 70 and 28 per cent. respectively. The best-welded plate had an average coefficient of quality of 0.83, or 78 per cent. of the coefficient of quality, 1.07 of the untreated plate; the worst-welded plate had a coefficient of quality of only 0.03. This illustrates the very considerable difference which may exist between an autogenous weld made by one firm and that made by another firm.

The electrically-welded plate showed slightly better results in the tensile tests, but the ratio of fractures outside the weld and at the weld was 3 to 1 as against 27 to 25, a circumstance which prevents comparison on the same basis. The considerable thickness of the weld also played an important part in the case of this electrically-welded plate.

Brinell tests gave for the original plate an average hardness number of 115.6; the average for the fifty-two autogenous-welded plates was 102.8, or 89 per cent. of the hardness of the original plate, measured outside the weld, and 108.2, or 94 per cent., of the hardness of the original plate, measured at the weld. The decrease of 11 per cent. in hardness represents approximately the influence of annealing. The electrically-welded plate was less hard than all the others, especially at the weld.

Impact-bending tests on notched bars were made on six specimens taken from each plate. The blow was always applied on the weld in a direction parallel to the joint. There were seventy-eight test specimens taken from the autogenous-welded plates, and six from each of the other plates. The report from which we quote enters into the details of these tests for each plate, from which it is gathered that the resilience of the metal had undergone a marked decrease owing to the welding operations—a decrease, in fact, that is larger than the decrease in tensile strength. The plate, which, in the matter of the execution of the welds, was one of the best, and which was in the front rank for elongation and malleability, was the last for resilience. Further, the plates which in the tensile tests had given bad results gave satisfactory results in the impact-bending tests. It would appear that in regard to resistance to bending under impact, the welds which lack homogeneity and are fibrous are superior to those which have greater uniformity and are more homogenous.

These same tests on the specimens taken from the electrically-welded plate all gave bad results, notwithstanding the fact that at the weld the thickness was approximately double the original plate thickness.

Impact-bending tests are important, and should always be adopted; moreover, an examination of the fracture shows the character of the weld itself, whilst in tensile tests a weld is reckoned good when the specimen breaks outside it. These impact-bending tests on notched bars afford a simple means of ascertaining what has been the influence of the heat treatment.

Various other tests were carried out on the same plates, including the attack of welded joints by an acid. The illustrations given in the report show clearly the soundness of certain welds and the imperfections in others. The report also contains micro-sections taken from the various plates.

Taken generally, those plates on which the consumption of oxygen and, consequently, the consumption of gas were the highest gave the better test results. The quality of the gas was not entered into, but it is well known that the gas must be pure, dry and fresh to give a good weld. It should especially contain no sulphur nor phosphorus, and for this reason it is not advisable to use lighting gas in the place of acetylene for important welds, lighting gas being insufficiently pure. The welding metal, wire or rods, should be pure Swedish charcoal iron. The joints to be welded should be opened out with care to a suitable angle and width, and the pieces to be welded should be firmly held together during the welding operations. Several of the plates had been deformed by the welding process, showing that the men who carried out the welds had not had sufficient practice in the lining up and holding together of the parts to be welded. The liquid iron of the joints exercises on cooling a retractile action, and if the pieces to be welded are not held firmly their edges shift even while the welding process is proceeding. In cooling, stresses are set up which lead to buckling. During welding, contraction can be counteracted to a certain

* "Essais de soudures autogènes de tôles de chaudières," organisés par la Société Suisse de Propriétaires de chaudières à vapeur, par E. Höhn, ingénieur en chef, Zurich.

* This being the product of the tensile strength by the elongation on fracture divided by 100.

extent by hammering; also, when the welding is completed, by annealing the piece. Hammering may also take place after annealing. Hammering with small hammers whilst the piece is still red hot improves the metal, but hammering should on no account be carried out at a temperature below red heat. One of the firms demonstrated how hammering could be successfully effected. As shown in Fig. 2, the inside edges of the large plate were slightly raised, and after welding in the smaller plate B, the work, whilst the metal was still hot, was hammered down level, as illustrated in Fig. 3. The piece, after welding is completed, should be annealed at a temperature between 700 deg. and 900 deg. Cent.; annealing is more satisfactorily done in a suitable furnace, but when this is not available it can be carried out with the blow-pipe.

The question of electric welding has been largely discussed of late years, and there are some who much prefer electric to autogenous welds. The tests referred to, made by the Swiss Society, do not afford any proof of the superiority of the former over the latter. The average results of the electrically-welded plate are, indeed, not equal to the average results given by the thirteen plates having autogenous welds. On the other hand, the firm which carried out the electrical welds for the Swiss Society does not deal with welding for steam-boilers, but only occasionally effects welding operations on steel castings. Moreover, the firm in question was very busy when it undertook for the Swiss Society the trial welding on the plate in question, and this may have had an influence on the results. In these circumstances it is not possible to establish an accurate comparison between the two processes. But the Swiss Society wishes to call special attention to the difference in the heat produced by the blow-pipe and that produced by the electric arc. In regard to energy, if the current be sufficient, the arc is far superior to the blow-pipe. But there are two points to be taken into account, one being the advantage of using the electric arc, since it melts the metal more easily and more rapidly, and allows the making of a real weld, and not simply a "sticking" together of the components; the other point is the danger of overheating the metal, which is more to be feared with the electric arc than with the much more regular heat of the blow-pipe. A joint which is welded under a steady and gradual heat is more likely to be a strong joint than one made by local and rapid heating.

THE BENDING AND TORSION OF BEAMS OF COMMERCIAL SECTION.

By E. G. Ritchie, B. Sc., University College, Dundee.

(*Concluded from page 50.*)

The Bending Tests.—The bending tests show that in general the experimental and theoretical values of E I agree closely. In some cases, however, a fairly large discrepancy exists between these two. This is probably due to the fact that the section was not by any means uniform throughout the length of the beam, and, moreover, a decided initial "set" was noticeable in most of the beams tested. These figures indicate roughly the discrepancy that might be expected from calculations based on the ordinary suppositions—that a beam is of uniform section throughout, and is perfectly straight from end to end.

One point of considerable interest is brought out in the above tests. It will be observed that in the case of the I-channel, and other sections, the values of E obtained are not equal for both axes of bending. Take the case of No. 4 I-section, for instance. The observed values of E, when the web is vertical and when the web is horizontal, are respectively 30.7×10^6 and 26.4×10^6 in.-lb. units. In the former case the web provides 14·5 per cent., and in the latter case only 0.64 per cent. of the total moment of inertia. Generally speaking, therefore, the modulus of elasticity of the metal in the flanges is less than that of the metal in the web; this want of uniformity being undoubtedly produced in the process of rolling. The above figures do not by any means represent the absolute values of E, depending as they do on a more or less inaccurate valuation of the moment of inertia What they do represent, however, is the relative elastic properties of the metal composing the flanges and web respectively.

In a series of experiments carried out by Professor Edgar Marburg, University of Pennsylvania, Philadelphia,* this want of uniformity in a beam section was very clearly brought out. In these experiments tension test-pieces were cut from the flange, web, and root respectively of several I-beam sections, and the values of E obtained by means of a Ewing's extensometer. These tests showed conclusively that the modulus of elasticity was not constant across the whole section of the beam, and a number of his tests bear out the above bending experiments, in that they showed the value of E for the flanges to be less than that of the web. This same want of uniformity is also noticeable in the other sections tested, and this fact seems to indicate that the method of rolling warrants more attention than has hitherto been paid to it. The rolling-mill has undoubtedly a deleterious effect upon some parts of the section, and arrangements should be made such that the metal forming, say, the flanges and root of an I-beam should suffer least from this cause in the process of manufacture.

The channel section was tested with the web both in tension and in compression; and it is rather interesting to note that the flexural strength is the same in each case. In the angle and T-sections also the flexural strength seems to be affected but little, whether the flange is submitted to tension or compression.

The rectangular sections show a much greater uniformity than do the other rectilinear sections, as one might be led to expect, since the metal composing these suffers much less deformation in the process of manufacture. Nothing need be said in regard to the tests on the solid circular sections. The tests on the hollow sections are of some interest. These were of solid-drawn steel, except the welded tube, which was of wrought iron. The value of E deduced from the experiments on the latter seems to be somewhat low, but as the internal surface of this tube was somewhat irregular, irregularities in the results were therefore to be expected.

Coming next to the solid-drawn sections, it will be seen from a glance at the tabulated results that the observed value of E is in each case abnormally low, the maximum value obtained being only 27.1×10^6 in.-lb. units. These sections were perfectly uniform both inside and outside. The tabulated results can therefore be relied upon. These facts indicate that the process of drawing weldless steel tubes has a considerable effect upon the elastic properties of the material.

The Torsion Tests.—The torsion tests bear out in a remarkable manner St. Venant's mathematical demonstrations regarding the inefficiency of corners and projecting points in a beam section, the extreme weakness of all commercial sections being at once apparent from a glance at the results obtained. The inefficiency of I and channel sections is especially noticeable, as one might be led to expect, since these sections have the largest number of projecting points and corners. Next in order come the T-section bars with three isolated points, and the angle bars with two points and a corner. The tests on the rectangular bars indicate that in such sections the greater the ratio $\frac{\text{depth}}{\text{breadth}}$ the less will be the efficiency of the section, and that when this ratio is equal to unity—*i.e.*, square section—the section has a maximum efficiency of about 86 per cent. of its theoretical strength. Expressions for the effective polar moment of inertia of the commoner sections, as deduced by St. Venant, have been tabulated in

Table III.

Type of Section.	Remarks.	Effective Value of $J = J^1$.
Solid ellipse	Major axis $= 2a$ Minor axis $= 2b$	$\frac{\pi a^3 b^3}{a^2 + b^2}$
Hollow ellipse	Major axes $2a$ and $2a_1$ Minor axes $2b$ and $2b_1$	$\frac{\pi a^3 b^3}{a^2 + b^2}\left[1 - \left(\frac{a_1}{a}\right)^4\right]$
Square	Side $= s$	$0.14\, s^4$
Rectangle	Length of sides b and d	$\frac{d\,b^3}{3}\left[1 - \frac{0.6\,b}{d}\left(1 - \frac{b^4}{12\,d^4}\right)\right]$
Any symmetrical section, including rectangles, in which the ratio of outside dimensions in any two directions in a cross-section is not very great	A = area of section. J = geometrical polar moment of inertia	$\frac{A^4}{40\,J}$

* *Engineering News*, vol. lxii., 1909, page 168.

Table III., from which the angle of twist over a span of 5 ft. per 50 in.-lb. of torque has been calculated for sections 12, 13, 14, and 21. Comparison of the results so obtained with the observed angle of twist for sections 12, 13, and 14 shows that the results are in very close agreement. The discrepancy in the case of section 21 is probably due to the fact that the section was not quite ellipsoidal. In a truly ellipsoidal section it is beyond doubt that St. Venant's equations will yield accurate results.

It will be seen from Table I., page 50 *ante*, that the dimensions of the channel beam are approximately equal to those of No. 5 I-beam section, except that the flanges of the former are slightly heavier than those of the latter. We should therefore expect the channel beam to offer a greater resistance to torsion than the I-beam, and this is what we find from a comparison of the experimental results. The difference, however, is not striking in view of the fact that not only are the flanges of the channel beam heavier than those of the I-beam, but in the former case the web is much better situated to resist torsion than in the latter case.

If we compare the small angle and the channel sections, we find that two angles of the same section as the smaller angle, placed together, would very nearly equal the section of the channel. This being so, it is interesting to note that the channel, although more than three times as strong in torsion as the angle, is only about one-third as efficient. Again, it will be seen that the T-sections are nearly similar to the I-sections. The larger T-section, while only about half the torsional strength of the No. 4 I-section, is more than six times as efficient. The smaller T-section, having a torsional strength approximately equal to one-fifth that of No. 5 I-section, is about twice as efficient, torsion in each of the above cases being considered as about the centre of gravity of the respective sections. The hollow rectangular sections present some points of practical interest as being analogous to the box-girder so much used in practice.

It will be seen by a reference to Table II. that the efficiency $\left[\frac{\text{observed}}{\text{theoret.}}\ C\ J\right]$ of the solid square section equals 0.8591, while that of the hollow square section is 0.8670. Also, it will be observed, the efficiency of the hollow rectangular section equals 0.6880. Now, from St. Venant's formula, it may be shown that the theoretical efficiency of the solid square section is 0.8434, while that of a solid rectangular section having the same dimensions as the hollow rectangular section (1.432×0.872) equals 0.6730. These facts indicate that the efficiency of any hollow rectangular section is approximately the same as that of a solid section of the same over-all dimensions, depends only on the ratio of depth to width, and decreases as this ratio increases. Table IV. has been deduced

Table IV.

Ratio $\frac{\text{Greater Side}}{\text{Lesser Side}}$	Value of K.	Ratio $\frac{\text{Greater Side}}{\text{Lesser Side}}$	Value of K.
1.0	0.841	3.2	0.286
1.2	0.820	3.4	0.260
1.4	0.756	3.6	0.236
1.6	0.688	3.8	0.215
1.8	0.614	4.0	0.198
2.0	0.5498	4.2	0.182
2.1	0.485	4.4	0.169
2.4	0.434	4.6	0.156
2.6	0.388	4.8	0.145
2.8	0.348	5.0	0.135
3.0	0.316	—	—

from the work of St. Venant, the multiplying factor K* being calculated for values of the ratio $\frac{\text{depth}}{\text{width}}$ varying from 1 to 5. This table shows the rapidity with which the efficiency of a box section, or of a rectangular section, diminishes as the ratio of depth to width increases.

Table V. shows how the effective value of J varies with a variation in the ratio depth ÷ breadth, the area of section or the weight per foot run remaining constant. From the tabulated results it will be seen that while K and J^1 diminish with an increase in the ratio, the relative diminution of J^1 is not nearly so great as that of K. The relative

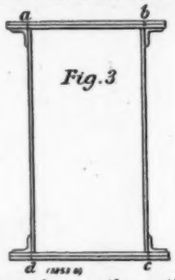
* K equals ratio $\frac{\text{effective polar moment of inertia}}{\text{geometrical polar moment of inertia}} = \frac{J^1}{J}$; *i.e.*, $C\,J^1 = K\,\frac{T\,L}{\theta}$.

TABLE V.

Ratio: $\frac{\text{Depth}}{\text{Breadth}}$	Depth.	Breadth.	Theoret. J.	K.	Effective J = J¹.
1.0	1.0	1.0	0.166	0.841	0.140
2.0	1.416	0.708	0.299	0.550	0.115
4.0	2.0	0.500	0.354	0.198	0.070
6.0	2.448	0.408	0.511	0.096	0.049
10.0	3.160	0.316	0.917	0.037	0.034

diminution of J^1 is approximately the same for hollow as for solid sections having the same over-all dimensions.

Owing to the inefficiency of the material in the corners and at the ends of the flanges of a typical box-section (Fig. 3) under torsion, the value of J or of J^1 for such a section should be computed not



on the whole area, but on the portion included by the rectangle *a b c d*.

Since an increase in depth renders a section more efficient to resist bending, the most effective value of this ratio, when both torsion and bending are to be resisted, depends on the relative values of the two moments. With zero bending-moment the section should be square. With zero torque experience shows that the ratio of depth to breadth should be between 3.5 and 5 for best results. With both torsion and bending the most economical ratio will usually lie somewhere between 2 and 3.5, its value increasing as the ratio of bending-moment to twisting-moment increases.

I-Sections.—A comparison of the results of the torsion tests on I sections Nos. 1 to 6, Table II., indicates that the ratio of actual to theoretical value of J diminishes with an increase in the size of the section. The penultimate column in Table VI. gives the values of K for these sections.

TABLE VI.

Section Number of Table II.	Approximate Dimensions.	Depth Breadth	Area "A."	J.	J^1.	K.	$\frac{A^2}{60}$
	in. in.						
1	8 ×5	1.60	8.02	104.0	1.04	0.010	1.07
2	3 ×3	1.0	2.43	4.90	0.099	0.0202	0.098
3	4½×1½	2.73	1.90	6.96	0.058	0.0083	0.060
4	3 ×1½	1.90	1.22	2.10	0.024	0.0114	0.025
5	2 ×1	1.97	0.682	0.364	0.0094	0.0260	0.0078
6	1½×0½	1.97	0.414	0.145	0.005	0.0344	0.0029

The value of J^1 in inch units is given with a fair degree of accuracy by the relationship—

$$J^1 = \frac{A^2}{60},$$

where A is the area of the section in square inches.

The last column of this table shows values of $A^2 \div 60$, while experimental values of J^1 are given in column 6.

From the tabulated results of Table VI. it appears that for sections 1 to 4 the formula gives results which are accurate within about 3 per cent. These are all commercial sections. The agreement is not so close for section 5, and is unsatisfactory for section 6. These two are not commercial sections, and the relative thickness of web and of flanges is much greater than in commercial sections, especially in section 6, in which the discrepancy is most pronounced. Probably, for all normal commercial I sections, the above formula will give results sufficiently accurate for purposes of design.

Angle, Tee, and Channel Sections.—An examination of the results of the tests on the angle, tee, and channel sections of Table II. (page 50 *ante*) shows that the value of K varies widely with the type of section. The value of J^1 is given within about 2 per cent. in every case by the relationship

$$J^1 = \frac{A^{2.3}}{m},$$

where *m* varies with the type of section. Values of K and of *m* are given in Table VII.

TABLE VII.

Section.	Mean Value of K.	m.
Channel	0.025	40
Tee	0.060	25
Angle	0.090	18

Compound Girder.—Experiments were also carried out on a compound girder consisting of two 8-in. by 4-in. commercial I-sections, distant 10.3 in. centre to centre, and tied together at intervals of 2 ft. 6 in. by plates across the bottom flanges. The value of J for this combination is 370 inch units, while the value of J^1 was found to be 2.05 inch units, giving a value of K = 0.0055. Calling A the total area of both sections, then

$$J^1 = \frac{A^2}{110},$$

as compared with $\frac{A^2}{60}$, for a single girder of the same total weight per foot run as the combined girder.

Tests on Hollow Box Sections filled in with Concrete.—Since in a hollow section torsion is accompanied by distortion of the webs and flanges, it was anticipated that by filling the interior of such a section with concrete this relative distortion might be reduced to some extent, and the section be stiffened in consequence. To test this point the hollow sections Nos. 15 and 16, Table II., were filled with cement grout, and after setting for four weeks were again tested in torsion. The effect of the cement filling is, however, not great. Thus, with section 15, J^1 without filling was 0.0483, and with filling 0.0508; while in section 16, J^1 was increased from 0.1645 to 0.1941 by the filling.

The tests on the circular sections, both solid and hollow, require no comment, as they only bear out what has previously been demonstrated—that the base formula holds absolutely for circular sections.

The values of the ratio $\frac{E\,I}{C\,J}$ have been tabulated, as this ratio is of great consequence in the solution of beam problems, where the beam is subjected to both bending and twisting moments.

The investigation demonstrates in a striking manner the enormous discrepancies that exist between the actual torsional strength of a beam and its strength as calculated from the ordinary torsional formula. The experiments on the square and rectangular sections amply confirm St. Venant's mathematical deductions, while for such sections as are used in practice, I, channel, tee, &c., the empirical formulæ deduced will give results accurate enough for all practical purposes.

The above investigation was carried out in the Engineering Laboratories at University College, Dundee, and the writer would beg leave to express his indebtedness to Professor A. H. Gibson, D.Sc., A.M. Inst. C.E., for the facilities given, and to Mr. J. C. Lamb for his assistance in carrying out the work.

THE LAKE MARGARET HYDRO-ELECTRIC POWER SCHEME.

(*Concluded from page 6.*)

HAVING dealt with the pipe-lines and the work carried out at the lake, we may now proceed to a description of the generating plant and the distribution system. The generating-station, an interior view of which is given in Fig. 26, on page 98, is a concrete building with a concrete floor. It has a steel truss-roof, lined inside with fibro-cement and covered with galvanised iron. The station contains four main turbines, each of a normal capacity of 1750 brake horse-power, driving three-phase 50-period 6600-volt alternators. There are also three exciter-turbines, each of a normal capacity of 100 brake horse-power, and the usual controlling switch-gear. The power generated is transmitted by duplicate overhead lines to a sub-station at the reduction works. It is here transformed and distributed to the mines and works, being employed for hauling, winding, air-compressing, pumping, lighting, &c. We will refer in more detail to the electrical arrangements after describing the hydraulic plant.

All the turbines, together with their governors, valves, and accessories, were designed and supplied by Messrs. Boving and Co., Limited, of Union-court, Old Broad-street, London, E.C. The main turbines, as we have already said, each have a normal capacity of 1750 brake horse-power. They have an overload capacity of 1925 brake horse-power, and run at 500 revolutions per minute. On test at full gate the turbines were actually found to have a capacity of 2300 brake horse-power at normal head. Details of one of the turbines are given in Figs. 27 to 30, on Plate XII. The water-supply to the inlet bends of the turbines is controlled by 12-in. hydraulic sluice-valves with by-passes, and arranged for combined hand and motor-control in a similar way to the 22-in. valves on the distribution-pipes, which we have already described. The water is directed on to the turbine-wheel by a polished nozzle in which there is a polished needle-valve which controls the amount of water passing, and is designed to keep the jet solid at all openings. The valve-spindle is of steel, while the head is of manganese-bronze, and is replaceable should wear set in, due to sand in the water. The arrangement of the needle-guide can be seen in Fig. 27, and in greater detail in the enlarged view given in Fig. 30. This latter view also shows the cup-leather gland, through which the spindle passes to the governing mechanism. The hydraulic pressure on the needle is balanced by a shoulder forming a piston and a coil spring, which has the effect that the governor has to exert a nearly constant force over the entire stroke.

The turbine-wheel has an over-all diameter of 6 ft. 6 in., and the water-jet has a diameter of 4 in. The buckets are of cast steel, polished on the inside and ribbed at the back, and are secured by double bolts to a cast-steel wheel, which is forced on to the shaft and secured by keys. The necessity for careful design in the buckets will be appreciated from the fact that when in operation each bucket meets at the jet an impact of over 4 tons at each revolution. The wheel is balanced, and is built to stand a runaway speed of 80 per cent. above normal. The wheel is housed in a cast-iron casing bolted to the bed-plate, which can be easily removed for inspection and repairs. The turbine discharge-pit has a steel-plate lining, reinforced with angle-irons, which forms a water-tight protection for the foundations. This lining is provided with a water-tight inspection-door, which is accessible from the power-station by a covered opening in the floor. The bearing-blocks are bolted to the bed-plate, as shown in Figs. 28 and 29, while the bearings themselves are white-metal lined and oil-ring lubricated. The position of the shaft is controlled axially by two collars at the outside bearing, and is provided with traps to prevent the creeping of water. The generator rotor, which is sufficiently heavy to act as a fly-wheel, is connected to the turbine through a leather band flexible coupling. This coupling not only makes up for any small discrepancy in the alignment of bearings or setting of foundations, but allows the generator-rotor to float slightly in an axial direction, and to balance itself without transmitting any thrust to the turbine-collar bearing.

The apparatus by which the automatic regulation is carried out is certainly the most interesting feature of the machines. It consists of Boving's patent system of combined deflector and needle regulation, worked automatically by the same governor. The apparatus is illustrated in Fig. 30. Above the jet there is a steel deflector, which is designed to deflect the whole jet away from the wheel when the deflector-edge reaches the centre line of the jet. The deflector is rigidly connected to the governor-shaft, and to each position of the governor and deflector corresponds a certain output—*i.e.*, a certain jet-diameter. The lever connections are arranged so that in normal operation, at all loads, the deflector stands just clear of the jet, ready to come into operation without any dead motion. The connection between the governor-shaft and the needle is made through an oil dash-pot, with a slotted-link connection. When load is suddenly thrown off, the governor brings the deflector into the jet instantaneously, thus diverting the water and reducing the output without at all affecting the flow of water in the pipe-line. The needle, which, owing to the spring behind it, has always a tendency to close when not checked by the governor, then slowly follows the movement of the governor and reduces the flow of water, adapting it to the new conditions resulting from the change of load. While the deflector diverts the full jet in about one second, the closing time of the needle can be adjusted (if necessary, during operation) up to 30 seconds, by means of a regulating-valve in the by-pass, by which the oil escapes from the dash-pot cylinder. When load is thrown

THE LAKE MARGARET HYDRO-ELECTRIC POWER SCHEME; GENERATING STATION.

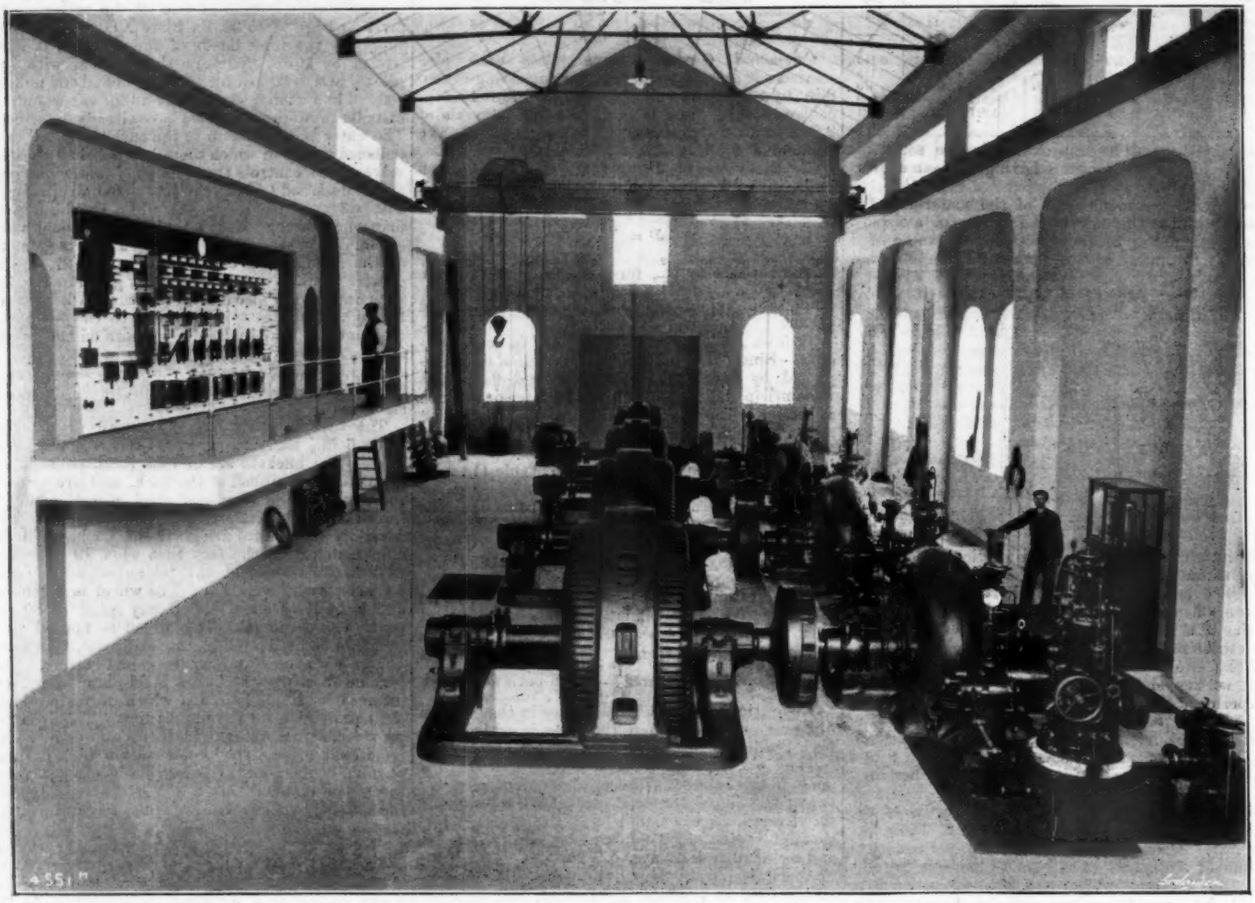


Fig. 26. Interior of Generating Station.

on, the governor lifts the deflector out of the way, and at the same time the needle opens quickly, the dashpot offering no resistance. The operation of the whole arrangement will easily be followed from Fig. 30, while parts of the mechanism can be seen in the views of the turbines after erection in the makers' shops, which are given in Figs. 34 and 35, on page 106. The system combines in a simple manner close speed regulation with perfect pressure regulation, and eliminates the necessity for installing automatic relief-valves, which are more complicated in design and are never absolutely synchronous in their opening with the closing of the needle-valve.

The deflector and needle are actuated by a servo-motor which is controlled by the governor, the servo-motor, pump, and governor forming a self-contained piece of apparatus. The governor itself is of the inverted-pendulum type, and is driven from the turbine shaft by a double open belt. The arrangement can be seen in Figs. 27 to 30. In the casing below the governor there is an oil-pump, driven by a separate belt, which supplies the oil pressure for operating the servo-motor. The pump is of the rotary type, consisting of two spur-wheels of skin-hardened mild steel. It normally carries a pressure of from 200 lb. to 225 lb. per sq. in., but can be made to run up to 300 lb. Below the pump there is an accumulator chamber, to which the pump delivers, the upper part of the chamber containing a cushion of air. A gauge-glass shows the amount of oil and air in the chamber at any time. The air is admitted by a valve connected to the pump suction-pipe, the mixture passing through a non-return valve into the accumulator chamber. On the chamber there is an adjustable overflow, or safety-valve, through which excess oil flows back to the low-pressure tank, being led on the way through cooling-pipes immersed in the tail-race.

The pressure oil is admitted to the servo-motor through a floating distribution-valve, the position of which is determined by a pilot-valve. The pilot-valve is operated by the governor through a bridle, which can be seen in the figures. At the fulcrum of the bridle there is a return gear which is operated from the regulating shaft. This gear is fitted with a compensating arrangement, which consists of a small oil dashpot and eccentric shafts and discs. By means of this arrangement the governor may be adjusted to give the same steady speed at all loads or a drop of speed between no load and full load up to 6 or 7 per cent., if preferred, for parallel running. The speed can be adjusted during operation by means of a small hand-wheel on the return-gear spindle, or also from the switchboard by a small direct-current motor fitted to the gear and having a double press-button suited for raising or lowering the speed. The load on machines running in parallel can thus easily be equally distributed among them, or transferred from one machine to another for changing over. The mechanical hand-regulating gear which is used for starting or stopping the turbine is connected or disconnected in any position simply by throwing over a lever, the automatic regulation being at the same time cut-off or thrown-in.

The turbines were designed to operate with a net head of 1050 ft. (455 lb. per sq. in.), to have a normal output of 1750 brake horse-power, a maximum output of 1925 brake horse-power, and to run at 500 revolutions per minute. The results of the official tests, carried out in March last, are given in the annexed table. All the electrical instruments used were tested by Messrs. Elliott Brothers' standard testing apparatus, while the water-pressure gauges were calibrated by the Government testing-gauge. As will be seen from the table, the water measurements were made both by the Venturi meters and by an overflow weir. This was installed in the tail-race. The figures obtained with the weir were about 3 per cent. lower than those given by the Venturi reading, but Messrs. Boving advise us that they certainly consider the

GENERATORS.							TURBINES.						
No. of Machine.	Standard Wattmeter Kilowatt.	Integrating Wattmeter Kilowatt.	Indicating Wattmeter Kilowatt.	Power Factor.	Efficiency per Cent.	Horse Power Output.	Gauge Pressure, lb. per Square Inch.	Venturi Meter, Gallons per Minute.	Weir Measurement, Gallons per Minute.	Theoretical Turbine Horse-Power.	Actual Turbine Horse-Power.	Turbine Efficiency per Cent. By Weir.	Turbine Efficiency per Cent. By Venturi Meter.	Guaranteed Turbine Efficiency, per Cent.
A	1501	1500	1565	0.795	95.0	2012.0	476	7610	7838	2600	2118	81.5	83.8	—
A	1201	1250	1260	0.8	95.6	1609.6	478	5706	5939	1982	1634	84.9	87.4	81
B	1200	1250	1260	0.8	95.5	1608.6	479	5725	5900	1970	1634	85.5	88.1	81
C	1212	1261	1273	0.8	95.0	1624.7	479	5783	5905	1971	1710	86.8	89.5	81
D	1219	1269	1279	0.8	95.1	1634.0	479	5800	5974	1994	1717	86 1	88.8	81

THE LAKE MARGARET HYDRO-ELECTRIC POWER SCHEME; 100-BRAKE-HORSE-POWER IMPULSE-TURBINE.

CONSTRUCTED BY MESSRS. BOVING AND CO., LIMITED, ENGINEERS, LONDON.

Fig. 31.

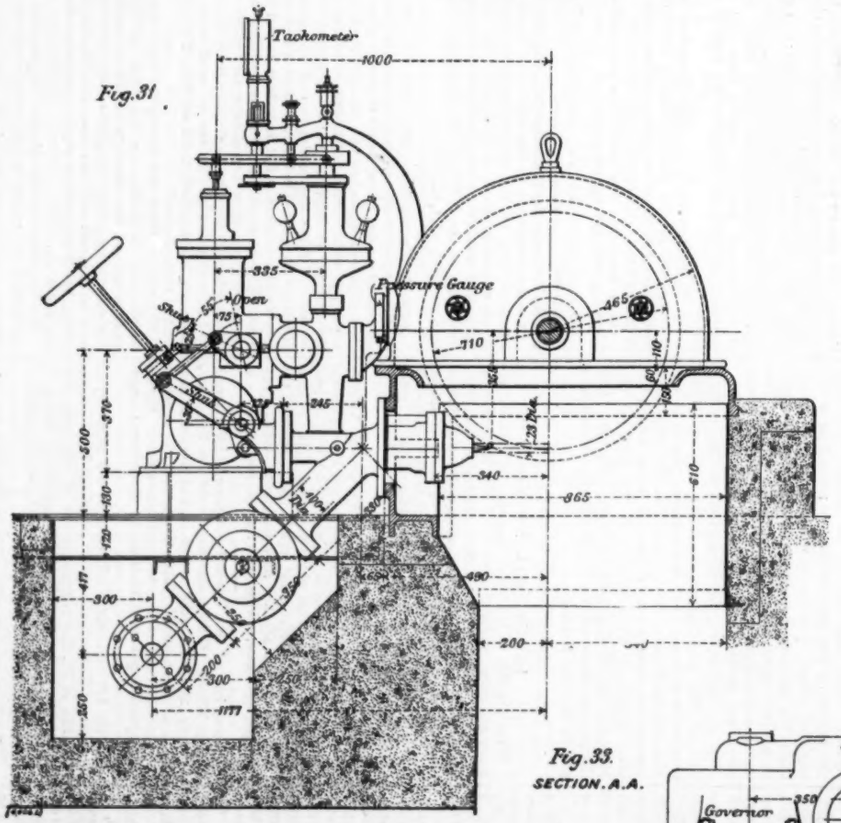


Fig. 32.

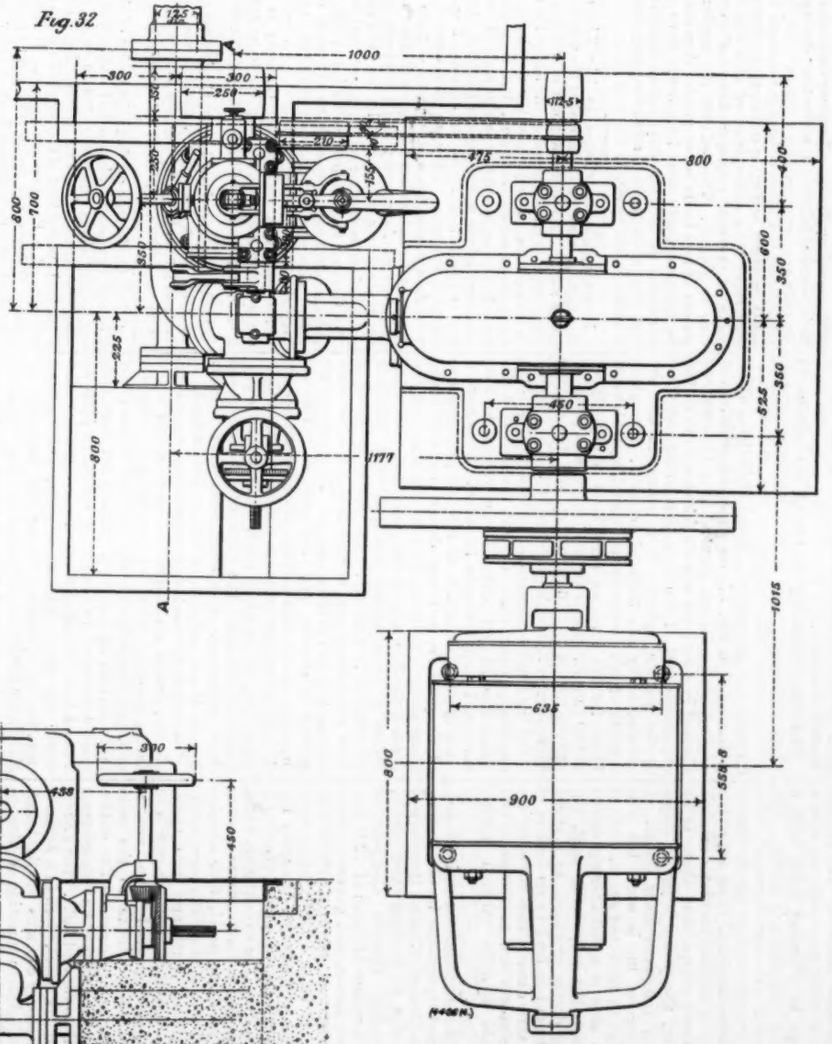
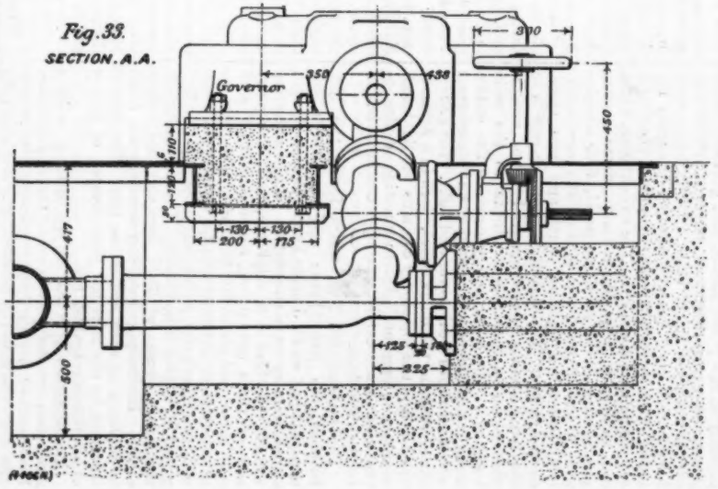


Fig. 33.
SECTION A.A.



latter the more reliable. With either set of readings the turbine efficiencies obtained were much above guarantee. The tests also show that at normal head and full gate the turbines give power 20 per cent. in excess of the guarantee, partly on account of the high efficiency and partly owing to liberal dimensioning. At half-load the efficiency is about 2 per cent. higher than at full load, and it only begins to decrease at about 40 per cent. load. The automatic speed regulation tests also gave remarkably good results for a load of 2000 brake horse-power suddenly switched off; the momentary speed variation was 6 per cent., and the permanent speed rise 0.7 per cent.

One of the three exciter turbines is illustrated in Figs. 31 to 33, annexed, while a view of the three sets in the builder's shops is given in Fig. 36, on page 106. These machines are each of 100 brake horse-power, and run at 1000 revolutions per minute. They also were designed and supplied by Messrs. Boving, and in so far as is possible they are similar to the main turbines. The overall diameter of the wheels is 2 ft. 6½ in., and the jet is 0.9 in. in diameter. The buckets are of special bronze cast on chills, which gives a better polish than could be obtained by grinding. The regulating-needles are of bronze and solid with the stem, which is directly connected to the governor. There

is no spring as on the main turbines. The sets are provided with heavy steel fly-wheels, so that a close regulation can be obtained even with a governor which works comparatively slowly. The deflector and dashpot can thus be dispensed with, the governor operating the needle direct without any danger from water-hammer. The automatic oil-pressure governor is similar to that described for the large turbines, except that there is no pressure accumulator, the pump being of ample dimensions to supply the servo-motor direct. A pressure of 40 lb. per sq. in. is used, but it is possible to run as high as 85 lb. per sq. in. without water-cooling. No electric speed-altering device is fitted, hand adjustment only being used, nor is the compensating device provided, as a slight variation in speed from full load to no load is of no importance in this case. The turbines are fitted with pressure-gauges and tachometers, and are connected to the exciters through flexible couplings.

The alternators, the exciters, the switchboard, and the other electrical equipment in the station, were supplied by the General Electric Company of Schenectady, N.Y., U.S.A., through their agents, the Australian General Electric Company of Melbourne. The alternators are each of 1200 kw. capacity at 0.8 power factor, and generate three-phase, 50-period, 6600-volt current. These test results are given in the table. Three of the sets, fully loaded, are at present required to supply the needs of the mines and works for power, the fourth set acting as a stand-by. The switchboard, which can be seen in Fig. 26, contains three exciter panels, one Tirrill regulator panel, four machine panels, two outgoing transmission line panels, one local power and lighting panel, and two valve-control panels. The high-tension switch-gear is of the hand-operated remote-control type, and is situated in a three-storey annexe to the main building. The lower storey contains the instrument transformers and a step-down transformer which furnishes local power and light. The middle storey contains the oil-switches, each in a separate cubicle, and the top storey contains the lightning-arrester equipment. Interconnecting cables in the station are carried through conduits buried beneath the floor.

The transmission line, which forms the link between the power-house and the works and mines, is just under 5 miles long. It runs straight across country to a sub-station at the reduction works. The line is in duplicate, there being two sets of three conductors, running parallel with each other, and about 100 ft. apart. The poles are of celery pine, obtained locally, and each is fitted with two cross arms, which carry the usual crown-glazed high-tension insulators. The six conductors themselves consist of 19/12 bare stranded copper cables. Electrolytic lightning-arresters are fitted in duplicate at each end of the line. The ground traversed by the lines has been cleared of timber as a protection against fire.

The sub-station is a concrete building, with a steel roof, on the same lines as the power-house. It consists of a main hall, containing the switch-gear and some motor-generators, &c., and an annexe containing the main transformers. These latter are of the single-phase, oil-insulated, water-cooled type, and are nine in number, each of 700 kw. capacity. They are arranged in banks of three, two banks being in constant use, and the third acting as a stand-by. These transformers step down the 6000-volt incoming current to 3000 volts. The main switch-gear is of the same type as that in the power-house. It controls the incoming lines, and both sides of the main transformers, as well as the outgoing 3000-volt lines to the mines and blowing plant. The gear also controls the supply of current to step-down auxiliary transformers, which yield 550-volt current for local use. The low-tension switchboard is one that has been in use for several years at the old steam-driven generating station at the reduction works. The sub-station also contains two 75-kw. motor-generators, which give a supply of current for general lighting. A small Pelton wheel is installed to form an alternative method of driving the generators of these sets, to ensure the continuance of the lighting in the case of a complete shut-down of the main plant. This Pelton wheel is worked from the smelter water-supply main, which runs close to the sub-station. There are also two motor-generators, which furnish 500-volt direct-current for a new electric crane at the converter plant. All the high-tension equipment in the station was supplied by the General Electric Company.

The only remaining feature of the scheme to which we have to refer is the installation of electrically-driven blowing-engines for the smelter-furnaces and converters. This installation, which is illustrated in Fig. 37, on page 106, replaces the original steam-driven plant. The blowers are situated in a concrete and steel house built on the slag-dump level of the reduction works and close to the smelting plant. It is connected with the sub-station by two 3000-volt circuits. The plant consists of six motor-driven centrifugal blowers. Those for the furnaces each have a capacity of 25,000 cub. ft. of free air per minute at a pressure varying from 4 lb. to 6 lb. per sq. in. The driving motors are of 920 brake horse-power. The blowers are of the double-ended balanced type, having three impellers at each end. On test the adiabatic efficiency was 75 per cent. The converter blowers have ten impeller wheels in series. They have a capacity of 3500 cub. ft. of free air per minute at 12 lb. pressure, and are driven by 250 brake horse-power. In these blowers the inlet is at one end and the discharge at the other, and a balancing device is consequently provided. The adiabatic efficiency is 73 per cent. All the blowers run at 3000 revolutions per minute and are fitted with tachometers and pressure-gauges. The bearings are oil-ring lubricated and water-cooled. The air supply to the blowers is drawn from the atmosphere through an outside tower at a considerable height above the engine-room level. The intake is provided with screens. The whole of the blowers and their switch-gear were manufactured by Messrs. Brown, Boveri and Co., of Baden, Switzerland.

The whole hydro-electric scheme has, since completion, proved an unqualified success, and while during operation there is a possibility of interruption, experience has shown that this is not likely to be serious at any time. It has not been considered necessary to retain the old steam plant as a stand-by. The change-over from steam to water-power was made without trouble, and without cessation of operation, during the last days of November last year. The amount of power generated at the present time is about 5000 horse-power. This, however, by no means represents the limits of the present scheme; while at a distance of about 1½ miles down the Yolande River from the present power-station, the water could be utilised again with a fall of about 400 ft. This would add about 40 per cent. to the maximum power which can be derived from the existing station.

In conclusion, we should say that in the preparation of this description we have received much assistance not only from the material placed at our disposal by Messrs. Boving and Co., but also from a technical description of the new works which has been prepared by members of the staff of the Mount Lyell Mining and Railway Company. Our thanks are due both to the Mount Lyell Company and to Messrs. Boving.

INDUSTRIAL NOTES.

The Minister of Munitions announces that he has made an Order, under Section 4 of the Munitions of War Act, 1915, declaring 298 additional establishments as controlled establishments under the Act, as from January 31, 1916. A total of 2720 establishments have now been declared as controlled under the Act, from the date of the first Order, July 12, 1915, to January 31, 1916, inclusive.

The London and Provincial Union of Vehicle Workers has decided to affiliate with the National Transport Workers' Union. The decision was arrived at as a result of a ballot of the members. The vehicle workers will therefore come within the purview of the triple industrial alliance of railwaymen, miners, and transport workers, which was formed recently.

A meeting of the Executive Council of the South Wales Miners' Federation was held on Saturday, January 29, at Cardiff, when it was decided, on a report of the General Wages Committee, to make an application, under the new Conciliation Board Agreement, for a 5 per cent. increase on the general wages rate.

On the 1st inst., Mr. F. A. Gibson, the secretary of the South Wales Coalowners, informed Mr. Thomas Richards, M.P., the representative of the men, that the coalowners will ask the Conciliation Board to reduce the wage-rate by 3¾ per cent., as the result of the joint audit.

The matter is to be considered at the next meeting of the Board.

The Board of Trade has issued a return dealing with cases brought by railway servants in regard to their hours of labour. It states that during the year the railways, working with a reduced staff, have been called upon to handle a largely increased volume of naval, military, and other traffic, often of an abnormal character. The consequence of this has been that many of the men employed have had to work for very long hours. The fact that the number of complaints of long hours is not greater than usual cannot be taken to imply that long hours have not been frequently worked, but that the men themselves recognise that under present conditions long hours must at times be inevitable.

In an article contributed to *The Times* of last Monday a neutral publicist makes the following statements:—". . . I made a point of visiting some of the great industrial centres in the Rhine Province and in Westphalia. Everywhere the moral depression is conspicuous among workmen, but it would be extremely unwise to infer from this state of things that organised labour would pay the slightest attention to any suggestion of strike or unrest. I spoke with scores of workmen. They are all of them dissatisfied with their present lot, and everyone of them has some vague sort of idea that 'things will have to change after the war,' but every single workman seemed to me firmly determined not to let his individual grievances influence what he calls his 'national work.' . . . The German Government is taking great pains to publish alarming reports about Germany in neutral papers with a view to showing workmen in the Allied countries an 'example' to follow. . . ."—The whole world now fully realises that Germany is ready to stoop to anything, and is not going to be caught napping by any kind of intrigue she may be guilty of.

At the meeting of the Labour Conference at Bristol, on Friday last, January 28, the following resolution was put forward, confirming the Executive's decision to allow Labour Members to enter the Coalition Ministry:—

"This Conference confirms the action of the Executive and the Labour Members of Parliament in allowing Labour Party representatives to enter the Coalition Government." The mover, Mr. Tom Shaw (Textiles), added that old shibboleths must go in the presence of a European convulsion. If Messrs. Henderson, Roberts, and Brace (the members now in the Ministry) were to withdraw from the Government the action would be misunderstood not only by the Central Powers, but also by our Allies. He was not troubling about Labour seats, but about splitting the Conference upon purely political issues.

Mr. Williams (general secretary, National Union of Railwaymen), in seconding the motion, stated that he did so on the ground that the party ought not to be in an isolated position, seeing that the existing Government was a national, and not a party, Government.

Mr. F. W. Jowett, M.P., argued against representatives of the Labour Party sitting in the Cabinet and participating in decisions taken without the consent of the country. He opposed the resolution.

On a card vote the resolution was carried. The following were the figures:—

For	...	...	...	...	...	1,674,000
Against	...	...	...	...	...	269,000

or a majority for the resolution of 1,405,000.

A later resolution, to the effect that "this Conference, in view of the unprecedented situation that exists, expresses the opinion that the best interests of the nation would be served by Labour representatives remaining in the Coalition Government," was passed by a majority of 1,127,000.

According to the *Manchester Guardian*, the report on the present state of employment in Manchester submitted to the Local Relief Committee states that at the Labour Exchange the demand for labour is, if anything, more intense, although, wherever possible, the scarcity of men is met by the substitution of women. "With the calling up of the groups, the difficulty is expected to become more pronounced, and considerable anxiety is felt as to how it will be coped with. There are still many women willing to undertake work, but it is not always easy to fit them in where labour is required, owing to their unsuitability and lack of training. So far as work of a clerical character is concerned, there are few, if any, suitable women unemployed."

The report states that among the men employed in warehouses as makers-up, &c., no unemployment exists; indeed, the shortage of labour tends to become acute. In some occupations women's labour has been introduced, and there seems a likelihood of the policy being adopted on a larger scale as the groups are called up.

The Registrar of the Mutual Registration Council had anticipated a large increase in the number of relief cases for registration during the winter months, but owing, he says, to the fact that the class of people

who usually receive relief at this time of the year are on the whole in a far better position than before the war, it has not been necessary for the usual relief to be given.

The Manchester Local Relief Fund stands at 122,719*l.* For the month of January the average weekly receipts have been 39*l.* The total payments out of the fund amount to 98,676*l.*, leaving a balance of 24,043*l.*

The question of "Women's Work During and After the War" formed the subject of a paper, by the Hon. Lady Parsons, read before the Royal Society of Arts, on Wednesday last, the 2nd inst. The lecturer reviewed the various fields open to women. In the field of engineering, she said: ". . . It is quite evident that if girls are keen to go into engineering at a time of stress like the present, they must take things as they are; but, at the same time, when one considers the enormous number of women employed on munitions—19,000—to meet the extreme needs of the country, it cannot be thought unreasonable to press for some facilities for those who have had an expensive education as well as for the unskilled women. A roomy hostel with civilised interior arrangements and meals decently served is the accommodation most comfortable and convenient for girls. Once the problem of lodging is solved, educated girls would not be long in setting to work to learn the routine of the shops, and then be ready to take advantage of such opportunities as may happen. But there must be a reasonable chance of employment at the end of training. Professional women cannot generally afford to give themselves a course of training, unless it is for some definite object. In engineering, as in medicine, few young men are entering the profession at present; but, so far, little provision has been made to supply their place with trained women. . . . A good lead has been given to engineering for women by the plucky and patriotic action of the week-end lady munition-workers at various large firms. At one firm some 300 ladies go down and keep the lathes running on Saturday and Sunday. The output of some of the ladies has created great astonishment among the ordinary workers and the skilled foremen. Already some of them can set the tools in their lathes, and some of the most skilled are quietly qualifying themselves as mechanics, the idea being for the week-end women munition-workers to bring their own skilled women mechanics with them; they would then no longer be open to the charge of keeping skilled men mechanics waiting on them on Sundays. . . ."

The half-yearly financial statement and monthly report for January, 1916, issued by the National Union of Boot and Shoe Operatives, gives several interesting figures from which we take the following:—

		£	s.	d.
Funds in hand, trade department		123,898	1	10
,, ,, sick ,,		8,494	7	9
,, ,, fidelity ,,		309	0	0
,, ,, political ,,		1,873	8	3
Total in hand, central office	...	134,574	17	10
,, ,, branches...	...	65,160	16	6
Total funds of the union ...	...	199,735	14	4

The union has 41,665 male and 9276 female members, or a total of 50,941 financial members, which, with 7432 probationary members, gives a grand total of 58,373. The number of financial members now serving with the Colours is 7685; in addition to this there are a number of probationary members also serving, which would bring the total number of members with the Colours to approximately 10,000.

The object of the new Norwegian Act dealing with accidents, which came into operation on January 1, 1916, is to insure the employees of industrial establishments against accidents connected with their work entailing disablement or death. The National Insurance Institution finds free sick aid and pays sick compensation during sickness caused by an injury after a lapse of ten days from the date of the accident. During the first ten days the district sick fund supplies the aid, provided the person in question comes under the scope of the law regulating cases of sickness, otherwise the National Insurance Institution does the needful. When the treatment for the injury comes to an end, and should the injured operative be completely incapacitated, he receives 60 per cent. of his former wages; he receives only a proportionate share of his former earnings for partial incapacity for work following an accident, provided the resulting decrease is over 5 per cent. of the earnings. The compensation in cases where the injury causes death remains the same as in the old law. The scope of the new law is somewhat widened, and comprises agricultural labourers where mechanical power is used, persons engaged at electric elevators and high-pressure heating installations, and transport by lighters not smaller than 50 tons; also men engaged in incidental work, when the aggregate annual wages are not below 500 kr. (28*l.*). When a job has been taken over by a contractor or by a set of men at a fixed price, the duty of insurance rests with the one who has taken over the work, if he can be looked upon as employer.

The Copenhagen builders (bricklayers) have gone out on strike to the extent of some 3000 men, and the men in eight other branches of trade, including textile and paper manufacture, have given notice to cease work. The Employers' Union in this connection has addressed a communication to the co-operating trade unions, and negotiations are pending with a view to avoid further stoppages. In regard to the builders they ask 70 öre (9½d.) per hour, whilst 55 öre (7½d.) per hour is offered. The Employers' Unions' communication to the trade unions recommended the withdrawal of the various notices of strikes, so that negotiations could proceed undisturbed. Should no agreement in the meantime be arrived at, 15,000 men will go out early in February, and at the same time 319 agreements expire, and will require renewal. The increase in pay demanded by the men is in many cases excessive; the builders have asked for a rise amounting to 60 per cent., having refused an offer of 10 per cent. rise from the masters; in the wood industry the men have asked for ten times more than the masters seem inclined to pay; and the labourers (of contractors, &c.) even demand an increase of 63 per cent.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

We give below a few data on several colonial and foreign engineering projects, taken from the *Board of Trade Journal*. Further information on these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

Australia: H.M. Trade Commissioner in Australia has forwarded specifications for tenders (as noted below) by the Victorian Government Railways. Sealed tenders, on proper forms, will be received by the Victorian Railway Commissioners, Spencer-street, Melbourne:—1. Up to 11 a.m., on March 15, for the supply and delivery of a belt-driven cold-metal circular saw and accessories (Contract No. 29,694). 2. Up to 11 am., on March 22, for the supply and delivery of a double wet tool-grinding machine and accessories (Contract No. 29,705). 3. Up to 11 a.m., on March 22, for the supply and delivery of a complete set of thermo-electric pyrometers with accessories (Contract No. 29,716). 4. Up to 11 a.m., on March 29, for the supply and delivery of a 13-in. centre by 14-ft. gap bed, sliding, surfacing, and screw-cutting lathe, and accessories (Contract No. 29,709). H.M. Trade Commissioner for Australia has also forwarded specifications in connection with a call for tenders by the Commonwealth Department of Defence (Navy Office), as follows:—Tenders will be received by the Director of Navy Contracts, Navy Office, Melbourne, up to noon on May 1, for the supply of cranes, lifts, locomotives, winches, air-compressors, &c., required for the Commonwealth Naval Dockyard, Cockatoo Island, Sydney, N.S.W. H.M. Trade Commissioner adds that he is informed that no conditions of tender peculiar to United Kingdom manufacturers have been issued, but that quotations should be f.o.b. home port, or c.i.f. Sydney, preferably the former. The Commercial Intelligence Branch of the Board of Trade is in receipt of a copy of a report of the South Australian Parliamentary Standing Committee on Railways, which recommends the construction of a line of railway, about 25 miles long, from Hanson to North Booborowie, at a cost not exceeding 163,000*l.* A further report of the Committee deals with the Yankalilla and Second Valley Railways. The Committee recommends the construction of a line from Willunga to Yankalilla, a distance of about 23 miles.

Portugal: With reference to the call for tenders for the execution of repairs to the gunboat Ibo, H.M. Consul at Lisbon reports that the contract has been awarded to a Portuguese firm. In his earlier report on the subject, H.M. Consul suggested that the successful Portuguese tenderer would probably require to obtain materials from abroad.

Spain: The *Gaceta de Madrid* notifies that tenders will be received at the Dirección General de Obras Públicas, Ministerio de Fomento, Madrid, up to February 11, for the construction of shelters on the España wharf in the port of Barcelona, at an estimated cost of 705,896 pesetas (about 28,000*l.*). The works must be commenced within a period of three months from the date of the award of the contract and completed within a further two years. Although this contract will probably be awarded to a Spanish firm, nevertheless the carrying out of the works may involve the purchase of some materials outside Spain.

United States of America (Philippine Islands): The Acting British Consul-General at Manila has forwarded a copy of a specification, together with conditions of tender, &c., for the erection of a new central sugar-mill, &c., at Isabela-Binalbagan, Philippine Islands. The contract includes the erection of buildings; the supply and installation of machinery and auxiliary plant, such as clarification plant, concentration plant, mixer, pumps, crystallisers, &c., to be electrically operated wherever practicable from an electric power plant, to be installed; the laying down of a railway of 36-in. gauge, suitable for the collection and transportation to the factory of the cane from the proposed district, and capable of conveying at least 1000 tons of cane per day; the supply and delivery of locomotives and rolling-stock, together with locomotive-sheds; the supply and erection of bridgework for the railway; the erection and fitting of offices; and the erection and installation of all necessary buildings, warehouses, wharf, telephone system, refrigerating plant, water and sewerage system, &c. Sealed tenders will be received up to 11 a.m., on April 15, by the Secretary, Central Sugar Board, Government of the Philippine Islands, Manila.

Republic of Colombia: The *Diario Oficial*, Bogotá, publishes the text of a note from the Junta Central de Hygiene to the Colombian Government relative to the sanitary measures which should be taken at the port of Buenaventura in view of the prevalence there of yellow fever. It is stated that, in addition to undertaking disinfecting operations and an active campaign against mosquitos, many houses will have to be demolished and reconstructed on hygienic lines, streets re-paved, and a complete sewerage system installed. Extensive defence works against the encroachment of the sea (which at high tide reaches the dwellings) are also necessary. The Junta is of opinion that the sanitary works should be entrusted to expert foreigners, and recommends the appointment of an engineer and a medical man experienced in sanitary measures to make an estimate of the cost of the works. The *Diario* also publishes the text of a law authorising the Colombian Government to complete all the necessary arrangements by December, 1916, at the latest, for the construction of a railway from Cúcuta or Puerto Villamizar to the Magdalena River. The Government is then to undertake the construction and equipment of the line, either by private or public contract. Specifications and conditions of contract in connection with the project will be published in Colombia and abroad. The Law further authorises the Government immediately to initiate steps, both in the Republic and abroad, for the contraction of a loan for the proposed works.

Brazil: The *Diario Official*, Rio de Janeiro, publishes a Decree authorising the Executive Power to open, in favour of certain Government Departments, extraordinary credits up to the total amount of 50,000,000 milreis (about 2,360,000*l.* at current rate of change) for the following purposes:—Assistance to persons affected through the drought in Northern Brazil; land, sea and river transport; settlement of national labourers; works of public utility in the zones ravaged by the drought, or in those parts to which the afflicted population has fled, including road and railway construction and the extension of existing railways.

Argentina: H.M. Minister at Buenos Aires reports that the Great Southern Railway Company has now carried out the greater part of the irrigation works in the valleys of the Rio Neuquen and Rio Negro, which it undertook by a contract dated September 24, 1910. The company was authorised to spend up to 4,032,000 pesos gold (about 806,000*l.*). This sum, it was thought, would be exhausted by the end of January, and the engineers supervising the works on behalf of the Government estimate that a further 270,000*l.* will be required to complete the undertakings. This need for extra expenditure is attributed by the company to the thoroughness with which the work has been carried out, supplementary works having in certain cases been undertaken in order to ensure complete safety in case of floods.

THE IRON AND STEEL INSTITUTE.—The annual and autumn meetings of the Institute will be held, by kind permission, at the Institution of Civil Engineers, Great George-street, Westminster, S.W., on the following dates:—Annual meeting, Thursday and Friday. May 4 and 5. Autumn meeting, Thursday and Friday, September 21 and 22.

JAPANESE RAILWAY DEVELOPMENT.—About 175 miles of new ordinary railway and 50 miles of light lines were opened for traffic in Japan in 1914. The most important new sections were 25 miles on the Tokushima line, 23 miles on the Sakata line, and 20 miles each on the Murakami and Gwanyetsu lines. The Tokaido line, connecting Tokio and the South, was damaged by typhoons in the summer, and extensive repairs were rendered necessary. Two of the most interesting railway events of 1914 were the completion of a new central station at Tokio, and the opening of a Government electric railway between Tokio and Yokohama. This railway, which runs side by side with the previously existing steam track, is 19 miles long.

THE "PRACTICAL ENGINEER" POCKET-BOOK AND DIARY.—A copy of the current edition of this very useful pocket-book has recently been received from the Technical Publishing Company, Limited, of 1, Gough-square, Fleet-street, E.C. It contains a section giving general information, including mathematical and other tables and data, and this is followed by sections devoted to subjects such as the properties of steam-boilers and accessories, steam-engines and turbines, condensers, gas and oil-engines, air-compressors, heating and ventilation, hydraulic machinery, engineering materials, machine-tools, beams and columns, power transmission, and reinforced-concrete construction; short notes on refrigeration, cranes, springs, patents, &c., are also included. This edition has been carefully revised and brought up to date by including the results of recent research and removing all obsolete matter. The principle of similarity as applied to steam-engine design has been made use of in the steam-engine section, and notes on the selection and use of lubricants for steam-engines, gas and oil-engines, turbines and compressors, have been included in the sections relating to these machines. The price of the pocket-book, bound in cloth, is 1s. 3d., or in "Peltine" binding, 1s. 9d., post free in both cases; foreign postage is 3d. extra for either style of binding.

AUTOMATIC HYDRAULIC CONTROL-VALVE.

We illustrate on this page an automatic hydraulic control-valve devised by Mr. E. C. Haarer, chief engineer of the London Hydraulic Power Company, of Hatfield-street, S.E. The apparatus has been primarily designed to be placed in the pipe-line connecting an accumulator in an outlying district with the mains of an hydraulic system. Such an accumulator to be of the greatest value must be freely responsive to the pressures in the mains, as with a restricted connection the accumulator effect is nullified. On the other hand, the difficulty with a freely responsive accumulator is its violent contact with the stops at the top and bottom limits of the stroke. The problem, therefore, was to keep the accumulator freely responsive throughout the whole of its ascending and descending range, and at the same time to prevent effectively, anything like violent contact with the top and bottom limit-stops. The device schemed out to meet these requirements consists of a combination of valves contained in one valve-body. These valves have the purpose of automatically controlling, diminishing, or preventing the flow of the liquid in either direction in the pipe-line, but at the same time they allow the fluid to flow automatically in a direction opposed to its previous motion, when the main valve is closed. Reference to Figs. 1 and 2 will make clear the construction and operation of the apparatus. Fig. 1 represents a section of the valve in elevation, and Fig. 2 a section in plan. Figs. 3 and 4 are an elevation and plan respectively showing the arrangement of the valve and gear as applied to various accumulators on the system of power mains.

Referring to Figs. 1 and 2 it will be observed that the valve has a double-headed piston A B working in a body having two ring ports C, D, with an annular space E between, connected to the outside of each port by a small by-pass E^1 fitted with the check-valves F, G. The length and stroke of the piston are such that when in mid-position both ports are uncovered, and there is therefore a clear passage through the valve in either direction. When the piston is moved over to either extremity of its stroke, it covers one of the ports, blocking the passage.

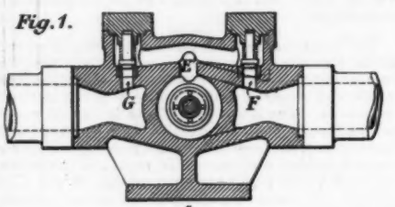
When the valve is applied to an hydraulic accumulator, suitable gear is fitted between the accumulator and the valve-spindle, arranged so that as the accumulator-ram approaches either limit of its travel it gradually moves the valve-piston over one or other of the ports, according to the direction of its movement, thus slowing down the motion and avoiding shock. The gear is at the same time arranged to bring the piston back to mid-position when free of the contact brackets on the accumulator.

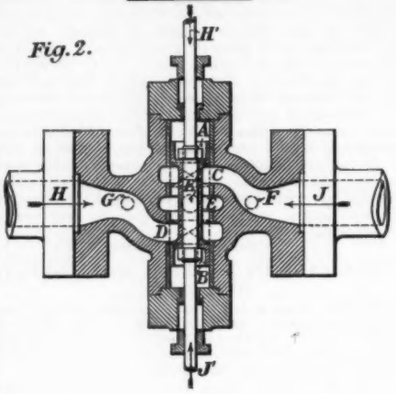
Assuming the water to be flowing into the accumulator in the direction of the arrow H, the ram will rise until it approaches the top of its stroke, when the gear will move the valve-piston in the direction of H^1 until port C is closed and the motion of the ram thus stopped. If during the closing (or closed) period the pressure should at point H be reduced by a draught on the main, water passing through the by-pass F in the direction of the arrow J would cause the accumulator-ram to descend, and in so doing move the piston back to mid-stroke, thus restoring the full area through the valve passage. On the descent of the accumulator to the bottom position the movement of the piston and water will be similarly affected, but in the opposite directions.

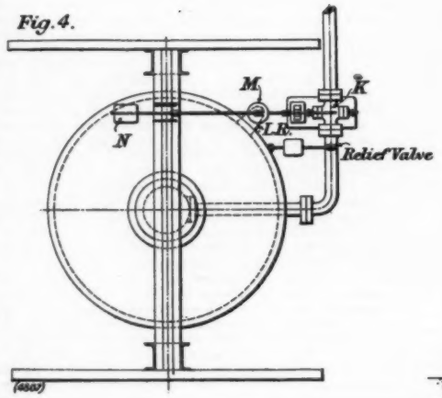
Figs. 3 and 4 represent an elevation and plan of an accumulator showing the arrangement of the control-valve and the application of the operating gear. The control-valve, already described with reference to Figs. 1 and 2, is placed at K in the pipe connecting the hydraulic main with the accumulator, the accumulator casing being provided with the contact brackets L and R, through which passes the tappet-rod V. In Fig. 3 the valve is in mid-position and the accumulator is shown approaching the bottom resting blocks at the point when the bracket R commences contact with the tappet S, thus depressing the lever W and gradually closing the valve through the spindle at U; as the accumulator ascends the weight T brings the lever back to mid-position. The operation at the top of the stroke is of similar character; the fixed bracket L lifts the sliding weight M off its supporting tappet P, thus allowing the weight N to raise the lever W through the tappet-rod V (the slot O in the link between the levers W and T allowing the necessary free motion for the upward travel of the lever) thus gradually closing the valve at U. As the accumulator descends the weight M again rests on the tappet P, thus overhauling the weight N and bringing the lever W back to mid-position. It will be observed that the valve and gear remain in this mid-position whilst the accumulator is moving between the bottom position, shown in Fig. 3, and the top position, when the bracket L lifts the weight M off the tappet at P.

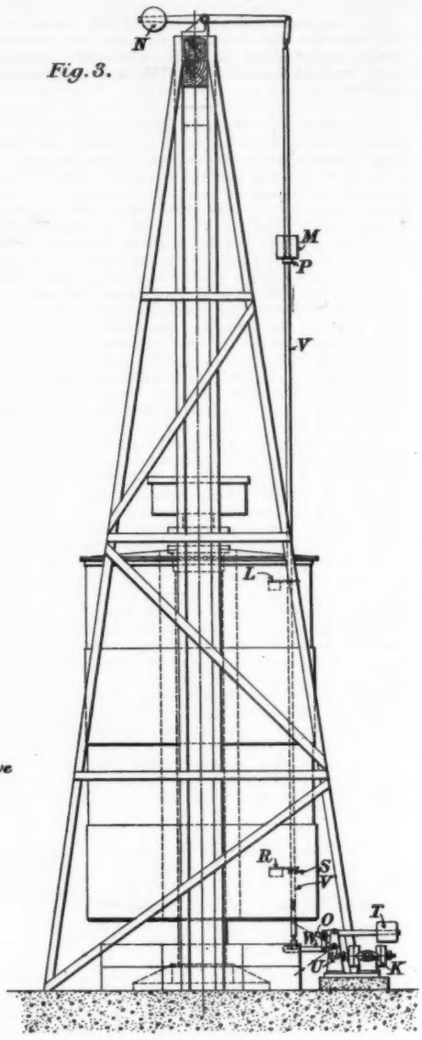
The valve has been successfully applied to a number of accumulators with good results, fully justifying the claims made for it. The valve is also applicable to any hydraulic machinery operated by a ram, such as that for working swing-bridges and dock machinery, and is particularly adapted for high-speed passenger lifts as a safeguard against the breaking of the hand-rope or other connection to the usual working valve.

AUTOMATIC HYDRAULIC CONTROL-VALVE.









THE FLOW OF AIR THROUGH NOZZLES.*

By Captain Thomas B. Morley, B.Sc., Associate Member, of the University of Glasgow.

(*Concluded from page* 94.)

Orifice Experiments.

An orifice—referred to as No. 7—0.196 in. in diameter, was made in a thin flat disc, as shown in Fig. 16, page 103. It was used with its flat side next the air-reservoir, and then, by reversing it, so that the bevelled side was next the air supply, another orifice form—No. 7A—was obtained. Experiments were made upon these orifices in the same manner as those already described.

Discharge Experiments.—As in the nozzle experiments, the temperature change was negligible except during the initial stages of the flow. It was found that the curves of log. pressure and time were slightly curved, as shown in Fig. 18, so that the discharge coefficients are not constant. Since it was considered that during the period of rapid temperature change the measurement of the mean value of $\frac{dT}{dt}$ for the air in the reservoir was not very reliable, the coefficients have been calculated for only that part of the flow during which the temperature was practically constant. As the available pressure was limited, this means that the coefficients have been found for pressures up to 50 lb. per sq. in. only.

The slope b of the curves of Fig. 18 was measured at several pressures, and the coefficients calculated from equation (3). The results are shown in Fig. 17. As was to be expected, No. 7A, in which the inner surface of the orifice plate was bevelled, and which had not a very sharp edge, has a higher coefficient than No. 7.

Velocity Experiments.—The orifices gave reaction and impact results very similar to those obtained for the nozzles, the impact attaining its maximum value at a distance of 9 in. from the orifices. The reactions and maximum impacts are shown in Fig. 19. Since the discharge coefficients have been found for pressures only up to 50 lb. per sq. in., the velocities also have been calculated only up to that point. The velocities for both orifices agree within the limits of experimental error. The mean values for both orifices are shown in Fig. 20. Those calculated from the reactions are practically equal to the theoretical, and, as in the case of the nozzles, those based on the impacts are higher, the difference this time being about 10 per cent.

General Conclusions.

In the flow of air through an orifice, it is evident that a *vena contracta* exists, the size of which depends upon the pressure of the air supply, so that the discharge coefficient is variable, increasing as the pressure increases.

A convergent nozzle with a rounded inlet may have a discharge coefficient of 0.98 if it is short; and, so long as there is no sharp change of curvature, alterations in the form of the entrance curve have very little effect upon the coefficient. The addition of a divergent part after the throat slightly reduces the coefficient, unless the taper is very gradual.

The efficiency of nozzles and orifices, as measured by the mean velocity of the jet produced, is very high indeed, becoming practically unity if they are of the proper form. For pressures up to 50 lb. per sq. in., orifices and convergent nozzles are practically equally good. (It may be remarked that Rosenhain found that in the case of steam up to 80 lb. per sq. in. an orifice was better than a nozzle.)

While the addition of a short and very gradually divergent part to a nozzle may slightly improve its efficiency,

* Paper read before the Institution of Mechanical Engineers, January 21, 1916.

it appears that, in general, and within the pressure limits of the experiments, a divergent part added to an air-nozzle is not an advantage, and if such a part has more than a gradual taper, it reduces the efficiency of the nozzle very seriously.

The effect of extra length is not so deleterious as that of a rapid rate of divergence. In the case of divergent nozzles, an entrance curve of about 0.5 in. radius gives an appreciably higher efficiency than one of 0.1 in. radius.

The author is unaware of any published results of experiments on the efficiency of air nozzles, except those published in 1906 by Professor Lucke, of Columbia University, New York. Professor Lucke then stated, on what the author considers entirely unsound grounds, that the efficiency of the expansion of gases in nozzles was extremely low. By 1912, however, Professor Lucke had changed his views, and stated that as good results could

Fig. 16. ORIFICE 7 (OR 7A)

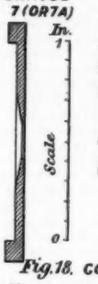


Fig. 17. DISCHARGE COEFFICIENTS FOR ORIFICES.

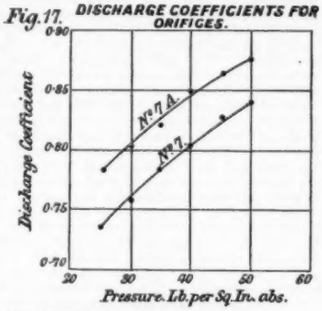


Fig. 18. COEFFICIENTS FOR ORIFICES. LOG PRESSURE & TIME

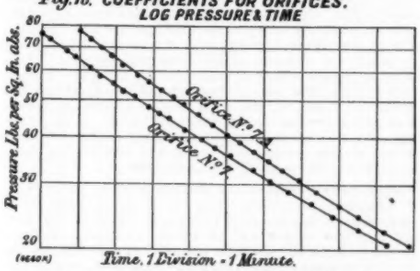
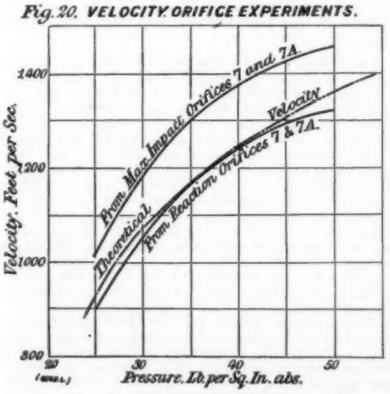


Fig. 20. VELOCITY. ORIFICE EXPERIMENTS.



be obtained in the case of air expanded in nozzles as in the case of steam. The author's experiments confirm, or, rather, even surpass, this latter view, provided the nozzles are of the appropriate form.

With regard to the discharge coefficients, it may be noted that the author has not in any case found values in excess of unity, as has been claimed by some experimenters.

Many engineers have some doubt as to the coefficients to be adopted when nozzles or orifices are used for the measurement of air, as, for example, in the testing of air-compressors, &c. In his paper on "Modern Condensing Systems," read before this Institution in 1913, Mr. A. E. Leigh Scanes quoted a formula, due to Leblanc, for the flow of air through a "properly designed" nozzle, which also was commended by Captain H. Riall Sankey. The author finds that this formula corresponds to a discharge coefficient of 0.97; it is therefore in quite satisfactory agreement with his results.

There is some discrepancy between various published coefficients for orifices. Probably the sharpness of the edge has considerable influence. Since, apart from this, the coefficient for an orifice varies with the pressure, the best plan for the measurement of air-flow by means of this type is evidently to employ a short convergent nozzle with a rounded entrance, and to adopt a coefficient of 0.98. The formula for the discharge, under maximum discharge conditions, then becomes $W = 1880 \frac{p A}{\sqrt{T}}$ where W is in pounds per hour, p in pounds per square inch absolute, A in square inches, and T in deg. Fahr. absolute.

The author is not aware whether turbines operated by compressed air have ever been employed, though he believes that they have been proposed for the propulsion of torpedoes, but in view of the high efficiency with which the expansion of air in nozzles may be carried out, and the advantages in many circumstances of the turbine over the reciprocating motor, there appears to be a distinct field in which, where power is transmitted by compressed air, the reciprocating motor might with advantage be replaced by an air-turbine.

SECTION II.—IMPACT AND REACTION OF JETS.

The comparison of the reactions of the air-jets with the forces recorded on a flat plate placed normally to the jets raises two points that call for explanation—namely, the

Fig. 19. VELOCITY EXPERIMENTS. REACTION AND MAXIMUM IMPACT. ORIFICES 7 AND 7A.

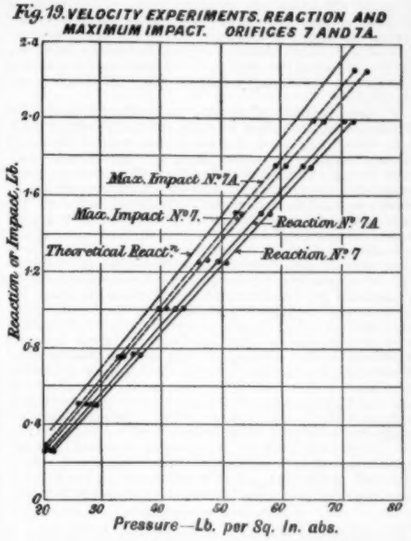
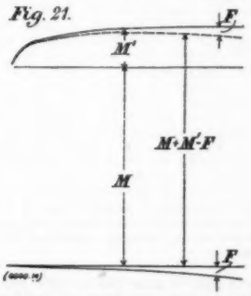


Fig. 21.



variation of the impact with the position of the plate, and the relationship between the true momentum per second of the jet, and the reaction and impact results. The variation of the impact with the position of the plate indicates that it is the impact which is influenced by some factor not considered in the elementary theory, and it is therefore the impact results which, in the first place at least, require investigation.

For the force on the plate to represent the entire momentum per second of the impinging jet, it is essential that the air as it leaves the plate should all be flowing in directions normal to its original direction. This was tested by introducing smoke or fine cotton threads attached to the end of a wire into the neighbourhood of the plate; it was found that the air always left the plate in tangential directions, and there was no evidence either of "rebound" or of residual momentum in the original direction.

Experiments were also made with impact plates of 12 in., 10 in., 8 in., and 6 in. diameter, with the result that the impacts on the 12-in. and 10-in. plates were found to be the same, that on the 8 in. plate very slightly less, and that on the 6-in. plate 2.5 per cent. less. The 12-in. plate used in the experiments is thus large enough to ensure that the impacts recorded are independent of the size of the plate. In order to test whether any appreciable reduction of pressure on the back of the plate took place, such as might have been caused by an induced air-current flowing radially outwards over the back of the plate to combine with the air leaving the face, a fixed guard-ring, 6 in. wide, was mounted so as to be concentric and flush with the impact plate, the radial clearance between them being 0.02 in. The function of this ring was to check the establishment of induced currents on the back of the plate, if such currents tended to be set up. The experiments showed that the presence of the ring had no effect whatever on the forces recorded.

It was considered that, with some of the nozzles at least, the expansion of the air might not be complete when it emerged from the nozzle, and that by the continuation of the expansion in the free jet the momentum would increase as the distance from the nozzle increased. The increased momentum would, of course, not be entirely in the direction of the jet, and the falling pressure in the free jet would also affect the impact. However, it seemed desirable to test the completeness of the expansion, and accordingly the pressure at a series of points along the axis of the jet was measured by means of a pointed static-pressure tube, 0.125 in. in diameter, having a circumferential ring of small holes similar to that used by the National Physical Laboratory in conjunction with a Pitot tube, and illustrated in the Proceedings of this Institution, 1904, page 298. The tube could be put into communication with either a Bourdon compound pressure and vacuum-gauge or a water-gauge, according to the magnitude of the pressure to be measured.

Experiments carried out upon nozzles 1 D, 2, and orifice 7 gave results which differed only very slightly. With nozzle 1 D and a pressure of 40 lb. per sq. in. above atmosphere in the reservoir, the pressures in the jet—measured in pounds per square inch above or below atmosphere—were 4.5 above at the exit from the nozzle, 4 below at 0.1 in., rising to 1 above at 0.25 in., then falling to 0.09 below at 1.6 in., 0.115 below at 3 in., and gradually rising to 0.015 below at 20 in. from the nozzle. The pressures at 0.7 in. to 1.2 in. from the nozzle were very unstable; outside those limits the pressures were steady. These results show that expansion is complete at or extremely near to the exit from the nozzle, and that while the impact changes considerably between points at distances varying from 2 in. to 14 in. from the nozzle, the pressure between these points remains nearly constant. The variation of the impact is not therefore due to changes of pressure—with corresponding velocity changes—in the free jet.

More light is thrown upon the matter by consideration of the effect of the air-jet upon the surrounding atmosphere. The pressure experiments show that there is a slight vacuum along the greater part of the axis of the jet, so that the surrounding air must tend to flow into the jet, and by means of smoke-bands and fine threads used to reveal the direction of the air currents round about the jet it was found that there was a flow into the jet in nearly normal directions, and this normal flow persisted up to points quite close to the impact-plate. Even when the plate was close to the nozzle there was a strong air-current along the outside wall of the metal blank in which the nozzle was bored, which curled in towards the jet as soon as it passed the end of the blank.

By displacing the pressure-tube from the axis it was found that the smallest perceptible effect on the water-gauge was indicated at a radius of 0.75 in. at 1.5 in. from the nozzle, and this radius increased in accordance with an approximately parabolic law up to 2.5 in. at 20 in. from the nozzle. These observations, though they represent only roughly the real boundary of the jet, are in tolerable agreement with the conclusions of Parenty and others that the jet is a paraboloid in form.

Experiments were also made with a Pitot tube placed in the axis of the jet at various distances from the nozzle. Making assumptions for the probable temperature, and therefore density in the jet, the velocity can be calculated from the readings of the Pitot and the pressure-tubes. As already explained, the velocity of the jets in question cannot be determined accurately by this method. The approximate velocities so found were, however, nearly in inverse ratio to the distances from the nozzle. Hence the cross-section of the jet is about proportional to the distance along the axis, and thus the evidence of these experiments too is that the jet is parabolic in form.

It is worthy of notice that when the Pitot tube was just at the exit from the nozzle, the pressure recorded by the gauge to which it was connected was equal to that in the reservoir; this confirms the conclusion previously reached that the efficiency of the nozzle is practically unity.

The parabolic form of the jet has a bearing upon the hypothesis which appears to the author to harmonise with the observed data. It seems probable that an "energy system" of circulating air is set up round about the jet, the external air flowing in nearly normally to the jet until it comes near the boundary of the jet, when it is rapidly accelerated, and, flowing along with the jet, is deflected with it at the impact plate.

The remainder of the path of the circulating air is completed in the atmosphere; it may be remarked in this connection that smoke-bands 3 ft. to the side of the nozzle were drawn into the jet when the discharge-cock was opened. The energy system derives the energy required to initiate it during the establishment of the jet when the flow is first started; but, once set up, it makes a very small energy demand upon the jet. Hence the induced air derives but little of its momentum at the expense of the original jet, with the result that the momentum of the total air deflected by the impact plate is augmented—that is, the force of impact on the plate is increased.

A complete mathematical expression for the system of stream-lines set up, together with the effect of frictional losses, and the consequent effect at the impact-plate, seems to be impossible. The nature of the variation of the impact may, however, be indicated as follows:—Let M be the momentum per second of the jet as it leaves the nozzle. Let x represent distance, measured along the axis outwards from the nozzle. (The distance x need not be measured from the mouth of the nozzle as origin.) The jet being parabolic, the velocity V is inversely proportional to x, and the perimeter of the jet is proportional to $\sqrt{x}$.

Considering the induced air added between sections at x and $x + dx$, it may be assumed that, since the air flows in normally, the area dA of the stream of induced air

before it reaches the jet is proportional to $d\,x$ and to the perimeter.

$\therefore$ $d\,A$ is proportional to $d\,x\sqrt{x}$.

Assuming the velocity of the induced air near the jet to be proportional to V the jet velocity, the added momentum per second $= d\,M'$ is proportional to $d\,A \times V^2$ or $= k \times d\,x \times \sqrt{x} \times \frac{1}{x^2} = k\,x^{-\frac{3}{2}}\,d\,x$. Hence, neglecting friction, the total added momentum per second at any point

$$= M' = \int k\,x^{-\frac{3}{2}}\,d\,x = C - \frac{D}{\sqrt{x}}.$$

M′ thus increases as x increases, but its rate of increase, while remaining positive, diminishes. The terms M and M′ are represented in form in Fig. 21 (page 103). The diminution of the momentum per second due to friction, F say, which is that part of M required to maintain the circulating energy system, has still to be allowed for. It is sufficient for the present purpose to remark that F must continuously increase as x increases, and that it is most probable that its rate of increase also increases. The curve of F will therefore be of the type shown in Fig. 21, and the total impact M + M′ − F will vary, as shown by the dotted curve, rising to a maximum and then falling. The curves of Fig. 7 (page 92 *ante*) are of this character.

On the above hypothesis the observed impact should approach the value M of the true impact of the original jet as x decreases. As there seems to be no reason why the reaction of the jet should not represent the true value of M, this means that as the plate approaches the nozzle the impact should approach the value of the reaction.

Most of the curves in Fig. 7, if continued, cut the axis of co-ordinates at points on the scale of impact which agree fairly well with the reactions. Complete agreement is hardly to be expected, on account of the very unstable pressure conditions at about 0.7 in. to 1.2 in. from the nozzle, and on account of the effect of the presence of the impact plate at short distances, these factors influencing the accuracy of the impact results at the shorter distances. In fact, at about 0.2 in. distance the conditions of flow between the plate and the end of the nozzle are radically altered and violent oscillations of the plate occur. It will be noticed that the ratio of the maximum impact to the reaction is in all cases nearly constant, having a mean value of about 1.1. This affords evidence in support of the assumption made that the velocity of the induced air added to the jet is proportional to the jet velocity.

It should be noted that it does not follow from the experiments, or from the hypothesis put forward, that the effect of the jets from the nozzles of a turbine upon the blades will be increased as the distance between them increases, for the conditions in a confined space and with moving blades are largely different from those of the experiments—namely, a jet in free atmosphere and impinging on a stationary plate.

An important deduction from the results is that, for the determination of jet velocities, it is better to measure the reaction of the jet rather than the impact.

The author desires to express his thanks to the University of Glasgow for the facilities afforded for carrying out the experiments.

A B C Guide to Patents for Inventions.—We have received a copy of the second edition of this guide. It is edited by Mr. Robert E. Phillips and Mr. A. Millward Flack, and is published by Phillips, 70, Chancery-lane, W.C. As its title implies, it gives information on patents for inventions under headings arranged alphabetically. The information is detailed and extensive, and will prove of great use to all classes of inventors.

The Institution of Naval Architects.—The annual meeting of this Institution will take place on Wednesday, April 12, and the following day, in the hall of the Royal Society of Arts, John-street, Adelphi, W.C. Owing to the continuance of the war, the Council have decided that it would be unsuitable for the customary entertainments to be given; the annual dinner and evening reception will accordingly not take place. The Council will be willing to present a gold medal to any person, not being a Member or Associate Member of Council, who shall at the forthcoming meetings read a paper which, in the judgment of the Council, shall be deemed to be of exceptional merit. The Council will also be willing to present a premium of books or instruments to the reader of any paper, not being a Member or Associate Member of Council, which paper shall, in the judgment of the Council, merit this distinction.

Whitaker's Almanack.—Year by year this publication becomes more interesting and more essential. This year naturally information regarding the war has been added to the other numerous subjects. It is treated from the point of view of Parliament, of the Dominions, of British losses, of cost, of finance, of labour, of land operations, of the loan, of munitions, of the Navy, of railways, and of warship losses. In addition there is a diary of the war giving the outstanding events of every day. The members of the Distinguished Service Order and the recipients of the Victoria Cross are also named. The following subjects are also dealt with:—Trading with the Enemy, British Imports, British and Enemy Trade, War Medals, Commercial Scholarships, National Dye Scheme, Labour and the War, and Trade Unions. The old subjects seem to be only slightly curtailed, so that the value of the book is not only maintained but also increased. The price is 2s. 6d. net at all booksellers.

NOTES FROM THE UNITED STATES.

Philadelphia, January 19.

The feature of the week has been the transfer of deliveries from the Atlantic seaboard, on account of railroad embargoes resulting from freight congestion, to the Middle West and the Rocky Mountain region. When the embargo is removed, through the dispersion of accumulated freight by ocean shipments, the heavy shipments to the interior will fall off largely and the shipments to the Atlantic Coast ports, especially to New York, be actively resumed. Iron and steel prices have not changed during the week. In consequence of increasing internal distribution there has been a marked increase in the production of structural material, ordinary bars, plates, sheets, skelp, pipe-line goods and tubes, and a lessened production in special bars, billets, sheet-bars, and semi-finished material; on account of this diversion, domestic deliveries are in many cases being made in advance of specified dates. Deliveries on new orders coming in cannot be promised before the third quarter. Domestic bookings continue to come in rapidly, as during November, when the highest level was reached, and in consequence increasingly remote dates for delivery are specified.

A large number of orders from Russia and other Governments, including an 8,000,000-dol. shrapnel order from Spain, will not be delivered until late in the third quarter. Efforts to secure shrapnel deliveries in July have failed. Domestic railroads have begun to place large orders for equipment with as much conservatism as urgent necessities will permit. Railroad earnings are large and are increasing; within three weeks or so, car orders accepted call for 190,000 tons of steel-bars, plates, and shapes, of which orders for about 100,000 tons have been recently placed, with negotiations for about 80,000 tons more pending. Among railroad equipment orders are requests for much bridge-building material, orders for the past week aggregating 25,000 tons; this sort of business will probably greatly increase, as railroad bridgework for a year or two past has been neglected as much as possible. The earnings of the United States Steel Corporation for the last quarter of 1915 were 47,000,000 dols. net, or over 50,000,000 dols. gross. The Bessemer Railroad Company has placed an order for 2000 steel cars, calling for 30,000 tons of steel plates. Shipyard requirements are becoming more urgent and more difficult to fill. Pig-iron production has seemingly reached its limit, the shortage of coke production interfering in some cases with full production. As heretofore noted, the enlargement of capacity is being hurried along as fast as possible.

Water-Power Schemes in Italy.—In Italy, with a normal annual import during recent years of about 10,000,000 tons of coal, the rise in price, reckoning it at about 4*l*. per ton or more, represents an aggregate of no less than 40,000,000*l*. per annum, as long as these unprecedented prices prevail. Of the 10,000,000 tons of coal about one-quarter goes to the railways, 1,700,000 tons to shipping, 1,200,000 tons to the iron industry, 3,300,000 tons to sundry industries, and 1,800,000 tons to gas works and domestic purposes. At present only about 340 km. of full-gauge railways are being worked electrically, whilst it is considered that electric traction might be adopted on 12,000 km. of main railway, which would mean a consumption of 200,000,000 kw.-hours. The cost of exploitation of water-power to the extent of another million horse-power (about 1,000,000 horse-power is stated as being exploited) is put at about 40,000,000*l*.

The late Mr. Wells Hood.—We regret to record the death, which occurred at his residence, Addison Mansions, West Kensington, on January 28, of Mr. Wells Hood, civil engineer. Mr. Wells Hood served a pupilage of seven years (1851-1858) under Mr. Thomas Cabry and Mr. Edward Wilson, in the engineering and locomotive department of the North-Eastern Railway. From 1858 to 1860 he surveyed large estates in Ireland, and acted also as contractor's engineering agent on the Longford and Sligo Railway under Mr. F. P. Barnes. He worked under Mr. Vignoles from 1860 to 1864 as sectional, and afterwards as resident, engineer, for one year, on the Tudela and Bilbao Railway, from the commencement of the surveys to the opening of the line. For the two years following, down to 1866, he examined and reported upon various projects for Mr. Gregory, Past-President of the Institution of Civil Engineers; he also carried out Parliamentary work in Wales and Somersetshire, and was in charge of the Kingford and Brent Railway. From 1866 to 1868 Mr. Hood was in practice on his own account, being principally concerned in the inspection of materials and railway plant and in making working drawings of these. From 1868 to 1870 he was in charge of 75 miles of the Great Indian Peninsula Railway, and of the reconstruction of many of the works. In the following year he laid out the Isle of Man narrow-gauge railway, and prepared Parliamentary plans and estimates in connection therewith for Mr. H. Vignoles. He acted from 1871 to 1872 as representative in South America of the Buenos Ayres National Tramways Company, and as resident engineer for the construction of the tramway and the requisite stations. Then, from 1872 to 1876, he was in the service of the Cape of Good Hope Government; first, as district engineer, acting as resident engineer on the construction of 30 miles, afterwards as resident engineer for the survey of 240 miles of narrow-gauge railway through a mountainous country previously reported upon as impracticable. For this work he received the thanks of the Colonial Government. Subsequently, Mr. Hood was for many years engaged as engineer and general manager of railway works in South America.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Glasgow Pig-Iron Market.—Business in the pig-iron market was rather dull last Wednesday afternoon, the transactions amounting only to 1500 tons, while the closing sellers' prices—81s. 7d. cash and 82s. 1d. per ton one month—showed a decline of 2½d. per ton from the previous day. A more active tone prevailed on Thursday morning, cash iron, after being done at 81s. 3d., steadied up, and closed at 81s. 7½d. per ton sellers. On forward account dealings were fairly brisk at 82s. one month, closing at 82s. 1½d. The turnover totalled 3000 tons. In the afternoon a distinct hardness was noticeable, when a restricted business of 1000 tons was done at 82s. 1d. one month. Closing sellers' quotations were 1½d. per ton over the morning's level. Further strength was gained on Friday morning, and although the dealings again only amounted to 1000 tons, prices went up about 4d. per ton. On forward account 82s. per ton was realised for fourteen days' iron, and 82s. 4½d. twenty-eight days, while closing sellers' prices reached 82s. 1d. cash and 82s. 7d. one month. This was completely eclipsed in the afternoon, however, one month's iron advancing to 83s. per ton, and closing with sellers at 83s. 3d., while the value of cash iron rose to 82s. 9d. per ton. On Monday forenoon an extraordinary development took place, the price of Cleveland warrants advancing to 84s. cash and 84s. 6d. one month—closing sellers. At 83s. 9d. cash and ten days and 84s. 3d. one month 1500 tons were dealt in. At the afternoon session this advance was not only maintained, but very considerably augmented, 1s. 5d. per ton being added to the high level already reached. Only a small business of 1500 tons was dealt in, 85s. 3½d. cash and 86s. per ton one month being realised for this quality. Sellers at the close quoted 85s. 5d. cash, 85s. 3d. twenty-one days, and 85s. 10½d. one month. Little movement took place yesterday (Tuesday) forenoon, and 4500 tons of one month's iron were dealt in at 86s. to 85s. 11d. per ton, with sellers at the close quoting 85s. 6½d. cash and 86s. one month. One month's iron fluctuated narrowly at the afternoon session between 85s. 10½d. per ton and 85s. 11d., closing quotations remaining at the same level as in the morning. A turnover of 2000 tons was reported. This morning, again, strong prices were very much in evidence, cash iron rising to 86s. 1d. per ton and closing at 86s. 3d., while up to 86s. 9d. was paid for one month's warrants, with sellers over at that figure at the close. In the afternoon one month's iron continued steady at 86s. 9d,, with sellers' closing quotation 87s. per ton, and 86s. 6d. cash. A limited business of 500 tons was done.

Sulphate of Ammonia.—Meantime there is nothing new to report in connection with the trade in sulphate of ammonia, the demand for which keeps very firm. The feeling that the supply will be totally insufficient for the demand during the next few months has necessitated the decision to suspend its export for some time, and in due course this should have a satisfactory effect. Prices both at Glasgow and Leith remain on the same basis as last week.

Scotch Steel Trade.—The greatest activity prevails in every steel-making establishment in the West of Scotland, and there is no limit to the output, more especially in regard to the requirements of Government, for the incessant cry is for munitions and more munitions. This, naturally, is absorbing the resources of the whole of the available plant to the further exclusion of ordinary mercantile business. Steel material of all kinds is much in demand for export purposes, France being a constant and pressing customer. The difficulty of obtaining satisfactory supplies of raw material—although much of this is now being produced in our own country—is adding to the anxiety of the steel-makers, as for some little time they have been unable to depend upon the supplies of ore, &c., from America, owing to the uncertainty and irregularity of delivery. This naturally adds considerably to the cost of all finished material, but as yet the Government proposal to limit prices has not been satisfactorily settled. Light sections are greatly in demand, and so are high-tensile steel bars for shell-making. While prices are firm, few steel-makers will quote unless against a definite specification. Boiler-plates remain steady at 13*l*. 10s. per ton; ship-plates, 12*l*. 10s.; and angles, 13*l*. 10s. or thereabouts, and all less 2½ per cent. discount. Steel bars run about 17*l*. 10s. per ton.

Malleable-Iron Trade.—Malleable-iron makers continue to report excellent business, every department being fully occupied at the moment. While much of this is on Government account, quite a considerable number of export orders are being put through, and with more favourable freight and transport conditions this could be greatly increased. For prompt specifications, "Crown" bars are still quoted 13*l*. 5s. to 13*l*. 10s. per ton, less 5 per cent., while for forward account probably a further 7s. 6d. per ton could with safety be added to this.

Scotch Pig-Iron Trade.—Despite the steady upward tendency in the price of pig-iron of all grades, the best possible conditions prevail. Considerable quantities are passing from producer to consumer both for home and export. Indeed, this latter branch of trade has much improved lately, and were it not for the limitations connected with licensing and the freight difficulty, it would be almost impossible to meet all the demands. Hematite is also greatly in demand, and the price may now be called 140s. or thereabouts per ton, an advance even on last week. The number of blast-furnaces in operation in Scotland during the week has been seventy-one, the same number as in the preceding week, and two less than at the same date a year ago. Prices of makers' (No. 1) iron have now reached an unprecedented figure, being in most cases almost double what they were

a year ago, as the following quotations will show:—Clyde, Calder, Summerlee, Langloan, 110s. per ton; Gartsherrie, 111s. (all shipped at Glasgow); Eglinton, 103s. 6d., Glengarnock, 110s. (both at Ardrossan); Dalmellington, 105s. (at Ayr); and Shotts, 110s. (at Leith).

Scotch Shipbuilding.—Shipbuilding of the ordinary mercantile kind has been veritably a negligible quantity during the past month, only one vessel having been launched on the Clyde, and none on either the Forth, Tay, or Dee. The Stalybridge, a tug of 150 tons, was built for the Alexandra Towing Company, Liverpool, by Messrs. Scott and Sons, Bowling.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—All qualities of steam fuel are in strong demand, inland works taking a big tonnage on contract account. On account of the restricted issue of licenses for export to neutral countries, shipments of this coal are not so heavy as a week ago, although higher prices are obtainable for inland sales. Very limited quantities are offered for disposal on the open market. A few inquiries are afloat in the market for "spot lots" of gas-fuel, but collieries are not able to deal with them. A strong tone exists in slacks of all descriptions, and merchants, who are, generally speaking, fully sold under contract, are unable to attend to the large number of inquiries which have come to hand recently. Owing to the difficulty experienced in working the order preventing the export of coking fuel, the prohibition has been withdrawn by the Board of Trade. Blast-furnace coke is a firm section at the maximum of 24s. per ton on rail at the ovens. Quotations:—Best branch hand-picked, 20s. 6d. to 21s. 6d.; Barnsley best Silkstone, 17s. 6d. to 18s. 6d.; Derbyshire best brights, 17s. 6d. to 18s. 6d.; Derbyshire house, 16s. to 17s.; best large nuts, 15s. to 16s.; small nuts, 14s. 6d. to 15s. 6d.; Yorkshire hards, 16s. 6d. to 17s. 6d.; Derbyshire hards, 16s. to 17s.; best slacks, 11s. to 12s.; seconds, 9s. 6d. to 10s. 6d.; smalls, 8s. to 9s.

Iron and Steel.—No success has attended the effort on the part of certain producers to force up the prices of forge and foundry irons, and it still remains well below the maximum. In Derbyshire foundry there has actually been a reduction, the present rate being 81s., or 6s. 6d. below the fixed maximum price. For Lincolnshire iron 2s. more is being asked, which, with the increased railway charges into the South Yorkshire market, is militating against any big business being done. For both Lincolnshire and Derbyshire forge, however, there is a steady demand. Hematite continues to occupy a very strong position. Makers are asking from 34s. to 36s. for East Coast mixed numbers, on truck, and, owing to the stringency existing, consumers are finding it exceedingly difficult to secure supplies. Contracts for next quarter are exceedingly difficult to obtain, as most of the producers have already sold their output for that term. Quotations for the third quarter of the year are well above present rates. The scarcity of labour forbids any hope of largely increased production. Important extensions to works continue to take place, and the steel-melting plant of the city will shortly be appreciably enlarged by the erection of Siemens-Martin furnaces to supplement those already in use. Some districts report an easing off in billets, but this is not experienced in Sheffield. Big prices are being paid for special lots where delivery is guaranteed. A steady supply continues to be imported from Sweden, though at greatly enhanced prices. Swedish billets, obtainable before the war at 12*l.* per ton, are now quoted at 25*l.*, and Swedish ingots, formerly 8*l.* 10s., are now 9*l.* 10s. Steel scrap continues very scarce, and shows a steady rise in price. High-speed steel finds a ready market for the whole of the output at maximum prices. Agents of Canadian munition firms have recently been purchasing in the city, and have only been able to secure supplies owing to being on Government work. The deliveries of alloys, especially tungsten, are fairly satisfactory, though some scarcity is experienced in ferro-chrome and ferro-silicon. Engineers and engineers' tool-makers are exceedingly busy.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Again values of Cleveland pig-iron are higher than they have been for over forty years. Not since 1874 have prices been up to the level they now stand at. In that year No. 3 g.m.b. realised 87s. 6d., and the ruling quality is now once more approaching that figure. Supply of Cleveland pig is insufficient to meet current requirements, and, owing to scarcity of labour, the output cannot be increased to any great extent; make is, however, to be augmented to some extent. A furnace is to be blown in at the Clarence Works of Messrs. Bell Brothers. The number of furnaces in operation on the North-East Coast now stand at 67, of which 28 are making Cleveland pig, 26 are producing hematite iron, and 13 are manufacturing special kinds of iron. To assist in satisfying customers stocks are being steadily drawn upon. Makers have little or none at their yards, and practically the only stock in existence is the 94,000 tons of No. 3 Cleveland pig-iron in the public warrant stores. During January 17,192 tons were withdrawn from the stores, and there are now warrants in circulation for 83,300 tons of Cleveland pig-iron. The general market quotation for No. 3 g.m.b. Cleveland pig-iron has risen to 87s., and further advance is confidently anticipated. No. 1 is still very scarce, and is quoted 90s. 6d. to 91s., and No. 4 foundry is round about 86s. 3d. No. 4 forge iron is plentiful, and no difficulty is experienced in purchasing this quality at 85s., whilst mottled and white iron are on sale at 84s. 6d. All the foregoing quotations are for early and forward delivery.

Hematite Iron.—East Coast hematite pig is almost unobtainable. There is practically none purchasable for supply before June, most makers having disposed of all they can make over the first half of the year, and there are no stocks to draw upon. Some manufacturers have committed themselves as far ahead as they care to, and they are not disposed to quote. There are buyers of Nos. 1, 2, and 3 at 135s. for delivery June next and onward, but it is no longer easy to place orders at that figure, and, as a matter of fact, 137s. 6d. has been paid, whilst up to 140s. is asked.

Foreign Ore.—The foreign ore trade presents no new feature of moment. The very heavy supplies coming to hand have enabled consumers to lay in stocks, and as a consequence they are not in the market to buy. On the other hand, sellers are well placed and are not inclined to make concessions. Market rates remain firm on the basis of 40s. ex-ship Tees for Rubio of 50 per cent. quality. Freights, Bilbao-Middlesbrough, are in the neighbourhood of 23s. Imports of foreign ore to the Tees during January reached 217,142 tons, and arrivals for the second month of the year promise to be on a good scale. For the first two days of February imports amounted to 14,373 tons.

Manufactured Iron and Steel.—As regards finished iron and steel, continued pressure of Government work is such as to still exclude ordinary commercial business. Quotations are strong. Principal market rates stand:—Common iron bars, 13*l.* 10s; best bars, 13*l.* 17s. 6d.; best best bars, 14*l.* 5s.; packing iron (parallel), 9*l.* 10s.; packing iron (tapered), 11*l.* 5s.; iron ship-plates, 11*l.* 10s.; iron ship-angles, 13*l.* 10s.; iron ship-rivets, 15*l.* 10s.; steel ship-plates 11*l.* 10s.; steel ship-angles 11*l.* 2s. 6d.; steel sheets (singles), 14*l.*; steel sheets (doubles), 15*l.*; steel strip, 12*l.* 15s.; steel hoops, 13*l.*; steel joists, 11*l.* 2s. 6d.; heavy steel rails, 10*l.* 17s. 6d.; and steel railway sleepers, 12*l.*—rails and sleepers net f.o.b., steel ship-plates, steel ship-angles, and steel joists net at works, and all other descriptions less 2½ per cent. discount.

Iron and Steel Shipments.—The shipments of iron and steel from the port of Middlesbrough during the first month of 1916 were up to expectations. But for shortage of labour they would have been heavier. Those of pig-iron amounted to 48,183 tons, as compared with 56,716 tons for the previous month, and 19,110 for the month of January last year. Of the pig cleared last month, 46,647 tons went to foreign ports and 1536 tons to coastwise customers. Once again France was by far the largest receiver, taking 29,260 tons; whilst Italy received 5729 tons; Japan, 4181 tons; Sweden, 1929 tons; Norway, 1895 tons; and the United States of America, 1500 tons. Of the 4382 tons of manufactured iron shipped in the first month of the year, 970 tons went abroad and 3412 tons coastwise; whilst of the 38,540 tons of steel cleared, 37,973 tons went foreign and 567 tons coastwise. India, with an import of 970 tons, was the largest buyer of manufactured iron. France was by far the largest importer of steel, receiving 26,319 tons; and other principal customers were:—Japan, 4745 tons; India, 3068 tons; and Natal, 1231 tons.

Manufactured Ironworkers' Wages Advanced.—The accountants to the Board of Conciliation and Arbitration for the Manufactured Iron and Steel Trade for the North of England have certified the average net selling price of iron rails, plates, bars, and angles for the two months ended December 31 last at 9*l.* 13s. 1.94d. per ton, as compared with 8*l.* 19s. 9.03d. per ton for the previous two months, and in accordance with sliding-scale arrangements there is an advance of 9d. per ton on puddling, and 7½ per cent. on all other forge and mill wages. The advance takes effect from the 31st ult. No iron rails were manufactured during the last two months of 1915, and the make of rails for the previous two months was under 3 tons. The total output for the two months ending December 31 was 8334 tons, as compared with 8031 tons for the previous two months.

Shipbuilding Orders.—The Prince Line, of Newcastle-on-Tyne, has placed orders for two passenger steamers with Messrs Palmer, of Jarrow, and for two passenger steamers with Messrs. Doxford, of Sunderland. These vessels will each be 450 ft. long, and have a carrying capacity of 8000 tons to 9000 tons. The firm of Messrs. Hawthorn, Leslie and Co., of Hebburn, has secured orders from the Commonwealth and Dominion Line, Limited, for three twin-screw steamers, of 10,000 tons each, for passenger trade between London and Australia.

The Chairmanship of Messrs. Richard Hill and Co., Limited.—Sir H. Lincoln Tangye has been elected chairman of the firm of Messrs. Richard Hill and Co., Limited, of the Newport Wire Works, Middlesbrough, in succession to the late Mr. Frederick William Manson, of the well-known Broad-street firm of Messrs. Back and Monson.

NOTES FROM THE SOUTH-WEST.

Cardiff.—The steam-coal trade has continued strong, and it is likely to remain so for the next fortnight. Tonnage arrivals have been fairly good, but loading pressure has been maintained. There has, however, been no great disposition to enter into fresh transactions for February, as buyers are unwilling to pay the very high prices demanded by colliery-owners. On the other hand, colliery managers, having regard to the reduction in outputs and the scarcity of coal abroad, are little disposed to make concessions. The best Admiralty large steam coal has been, to some extent, nominal; secondary qualities have brought 33s. to 35s.; best bunker smalls, 19s. to 19s. 6d.; and cargo smalls, 12s. to 15s. per ton. The best household coal has realised 23s. to 24s. per ton; good households have brought 21s. to 22s.; No. 2 Rhondda large, 29s. to 31s.; and No. 2 smalls, 16s. to 17s. per ton. The latest quotation for patent fuel has been 28s. to 32s. per ton. Special foundry coke has realised 46s. to 47s.; good foundry coke, 40s. to 45s.; and furnace coke, 33s. to 36s. per ton. As regards iron ore, Rubio has made 37s. to 39s. per ton upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

Western Trade Matters.—Negotiations are pending for the sale of a controlling interest in the Barry Graving Dock and Engineering Company, Limited, to the Cardiff Channel Dry Docks and Pontoon Company, Limited. It is proposed that the Barry Graving Dock Company shall continue as a separate undertaking, but that the Cardiff Channel Company shall purchase, at the price of 21*l.* per 10*l.* share, three-fifths of the share capital. Including debentures, the Barry Graving Dock Company has altogether a capital of 238,000*l.*; the dividend upon its ordinary shares for 1915 was at the rate of 11 per cent. per annum.—At the annual meeting of the Field Line, Cardiff, a dividend and bonus of 25 per cent. in all was declared for 1915. The chairman observed that the tonnage which had been requisitioned by the Government was far in excess of what was needful; if the Government prohibited the importation of all unnecessary goods, a substantial number of ships would be available for their needs.—The steel trade at Landore, Morriston, and Pontardawe is in a satisfactory condition; a slight improvement has been observable in tin-plates.—The directors of the Cardiff Gas Light and Coke Company recommend a dividend on the consolidated stock at the rate of 5 per cent. per annum for the second half of last year. The rise in coal prices has, of course, materially increased the cost of production; but the demand for gas has steadily improved, notwithstanding restricted public lighting and drastic limitations of business hours.—At a meeting at Cardiff to consider current freight rates, Lord Rhondda said he was glad to find that Cardiff shipowners recognised that freights were too high, and that they were going to take a leading part in helping the Government to reduce them. It was agreed at the meeting that steps should be taken at once to increase the effective supply of shipping by diminishing the extent to which vessels engaged by the Admiralty are now kept idle, and by stopping the employment of vessels in unnecessary trade during the war.—The steel single-deck steamer Dawlish, which was sold by Messrs. Anning Brothers in June to Mr. P. Samuel, Cardiff, for 41,000*l.*, has now been resold to the Stella Shipping Company, Limited, Cardiff, and she is to be renamed the Stellina; she was built at Stockton in 1898, and she carries 5800 tons dead-weight.—The steel single-deck steamer Ellerslie, 3854 tons gross, built at South Shields in 1906, carrying 6700 tons dead-weight, and hitherto owned by Messrs. Hutchins Brothers, Cardiff, has been sold to British buyers for 90,000*l.*—The directors of the Cardiff Railway Company recommend a dividend of 1 per cent. upon the ordinary stock for the past year; for 1914 no dividend was paid upon the stock; for 1913, it received 1 per cent.; for 1912, ¾ per cent.; and for 1911, 2 per cent.—The Argentine Naval Commission is inviting tenders for 10,000 tons of Welsh steam coal for early shipment, while the Spanish Government requires 20,000 tons, to be delivered over February and March. All offers will be necessarily subject to the British authorities releasing coal for shipment of the qualities required.—The directors of the Bristol and South Wales Railway-Wagon Company, Limited, recommend a dividend of 3s. per share, making 14 per cent. for the past year, adding at the same time 2000*l.* to the reserve and carrying forward 1987*l.*

COMPANY REGISTRATIONS IN 1915.—The war, according to the *Investors' Guardian*, appears to be having a cumulative effect in checking the formation of new companies. The returns for the second half of 1914, the first war period, showed a drop of 36 per cent. in the number of registrations, those of the first half of 1915 declined 44.7 per cent., while for the second half of 1915 the number is 16 per cent. below that of the corresponding half of 1914, and 46.3 per cent. below the figures for the corresponding period before the war. The figures of the nominal capitalisation of the registrations show the same movement, but in a more emphatic degree, the decline from pre-war standard (for corresponding half-years) being respectively 48, 58.5, and 70 per cent.

THE BRITISH ELECTRICAL AND ALLIED MANUFACTURERS' ASSOCIATION.—The annual general meeting of the British Electrical and Allied Manufacturers' Association was held at the Connaught Rooms, on Thursday, January 20. Mr. F. R. Davenport (Willans and Robinson, Limited), chairman of the Council, presided. After submitting the report and balance-sheet and referring to the probable situation after the war, the chairman said that with a view to organising and extending the export work of members, additions had been made to the export staff, and overseas committees had been appointed in India, Australia, and South Africa. Others, it was hoped, would be shortly appointed. In the discussion which followed, reference was made to the unsatisfactory position in regard to patents. Practically all members were now controlled firms, and their patents were naturally in a state of suspension, although patent fees had to be paid. This meant that the useful life of the patent would be shortened by the duration of the war. It was considered that, notwithstanding the unsympathetic attitude of the Board of Trade, the request for compensation should be persevered with.

THE LAKE MARGARET HYDRO-ELECTRIC POWER SCHEME; TURBINES AND BLOWERS.

(*For Description, see Page 97.*)

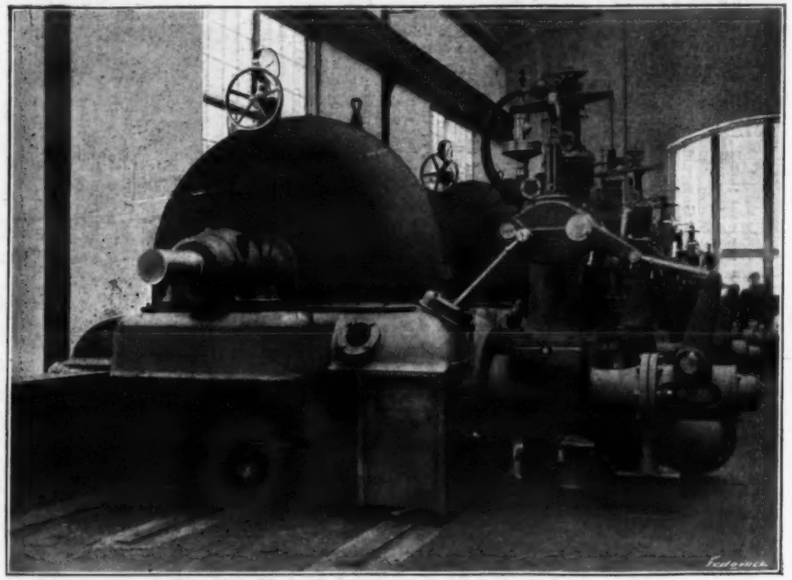


FIG. 34. MAIN TURBINES IN BUILDERS' WORKS.

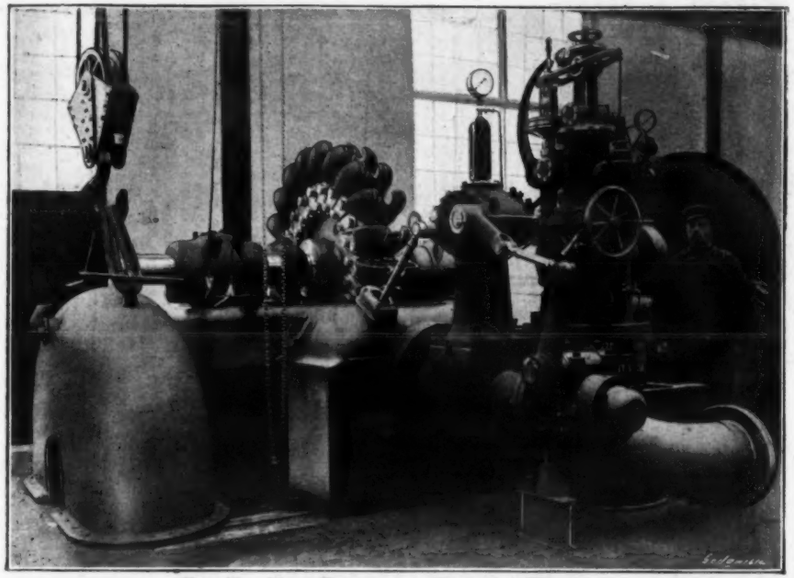


FIG. 35. MAIN TURBINES IN BUILDERS' WORKS.

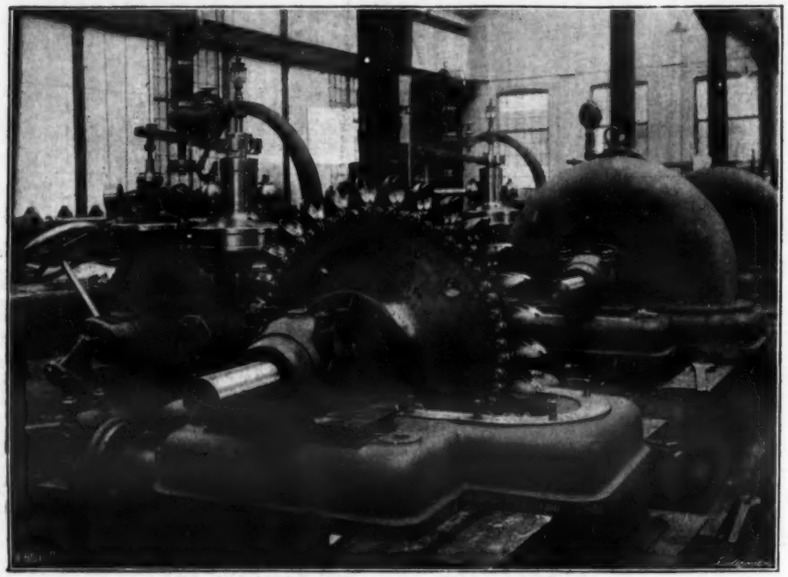


FIG. 36. EXCITER-TURBINES IN BUILDERS' WORKS.

FIG. 37. ELECTRICALLY-DRIVEN BLOWERS.

THE LAKE MARGARET HYDRO-ELECTRIC POWER SCHEME DE

CONSTRUCTED BY MESSRS. BOVING CO.,

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Fig. 27

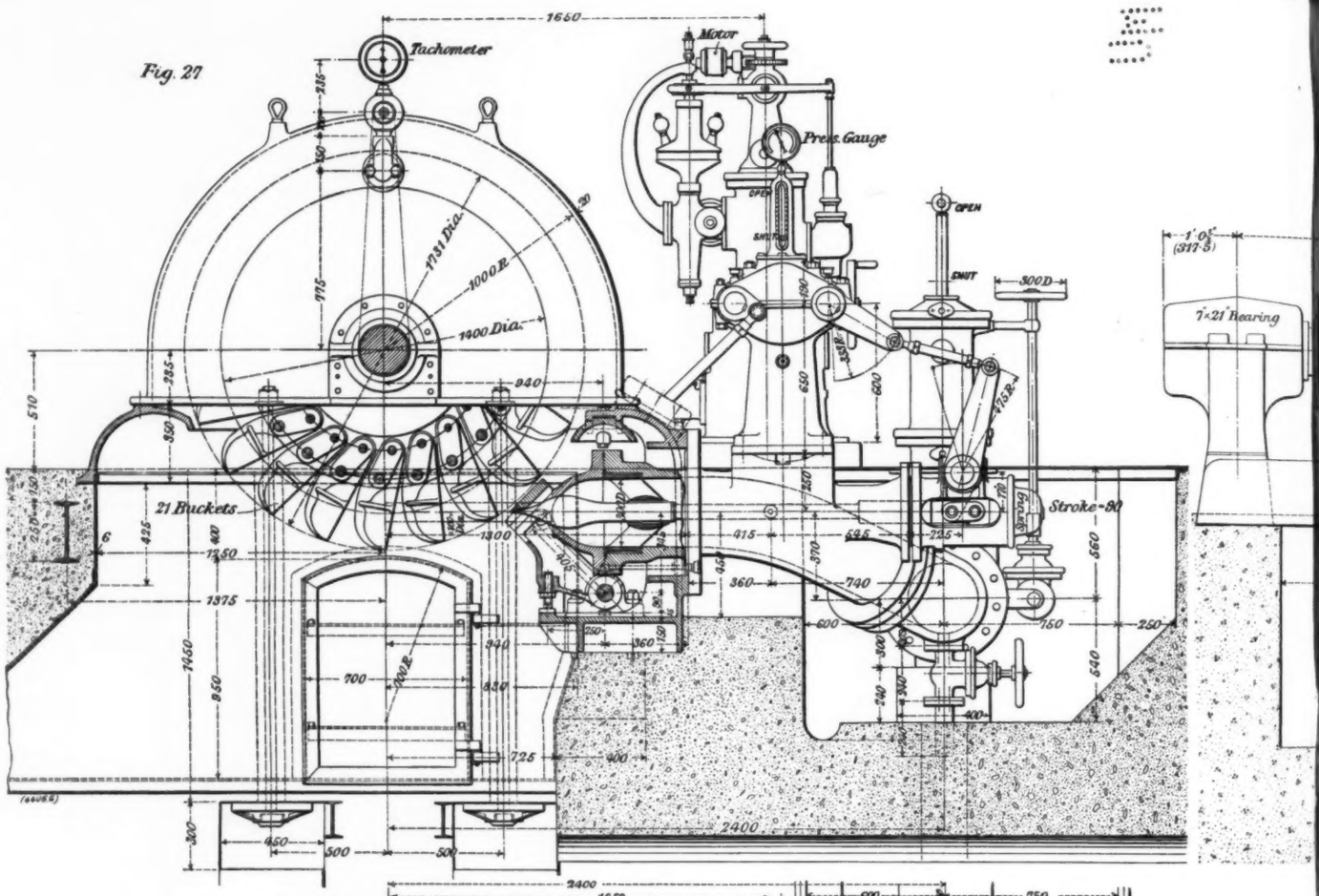
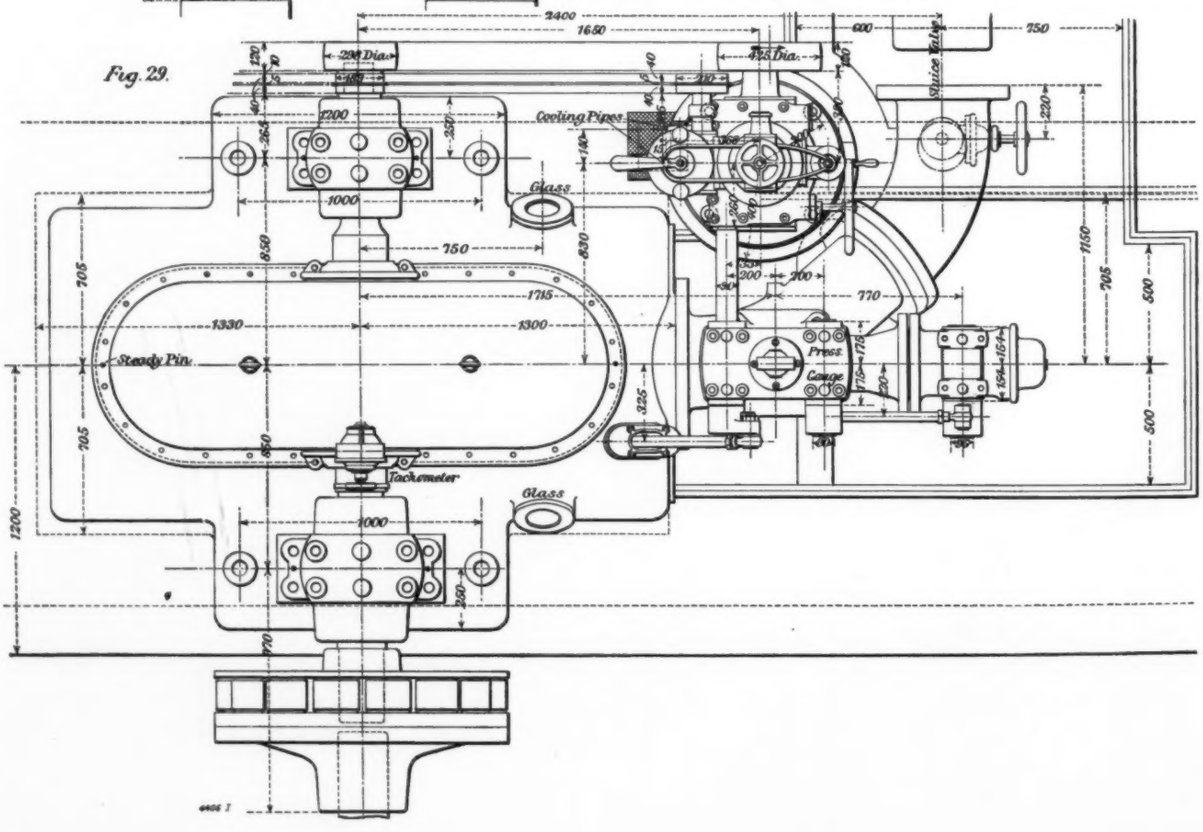


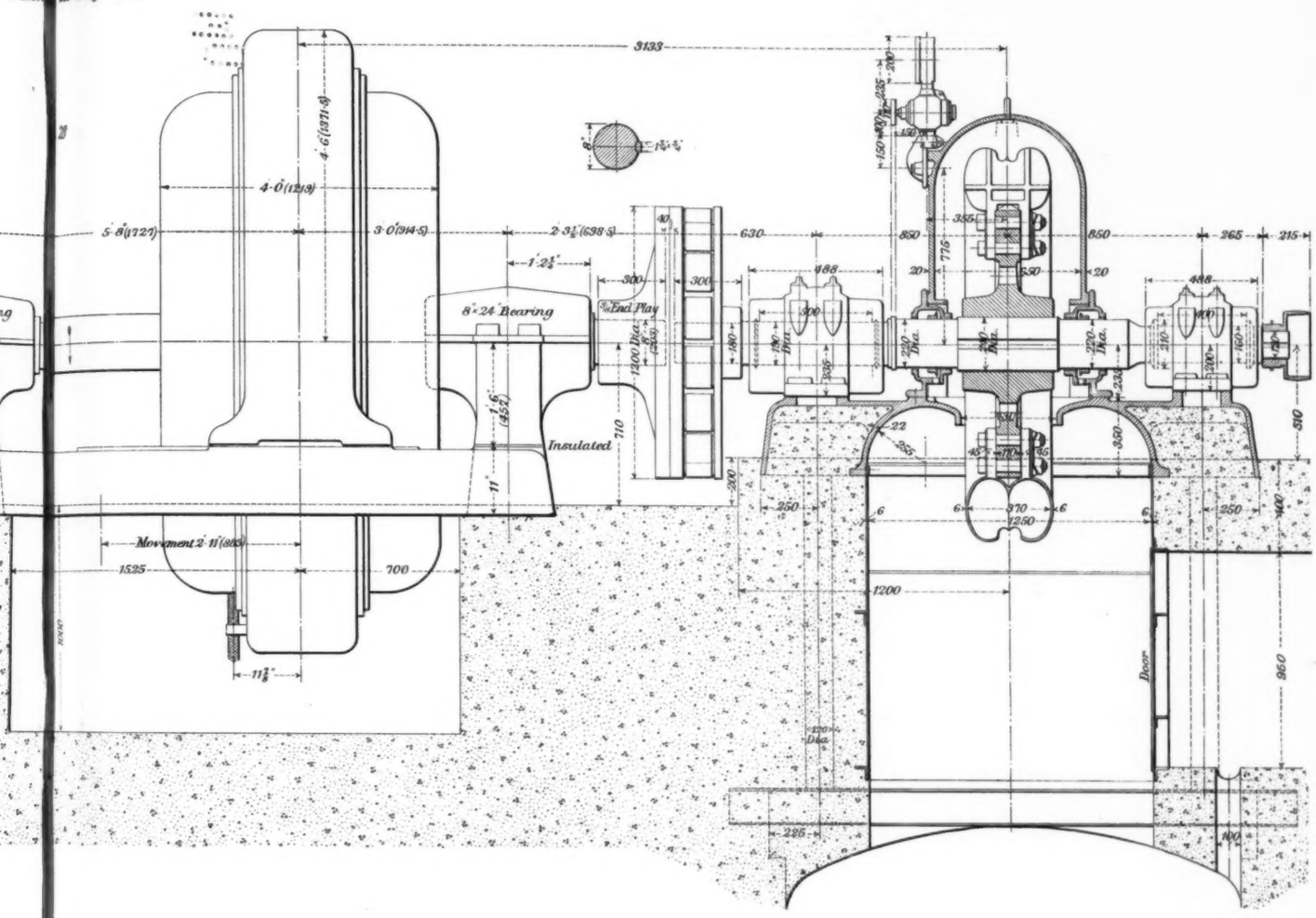
Fig. 29.



DETAILS OF 1925 BRAKE-HORSE-POWER IMPULSE TURBINE.

VING CO., LIMITED, ENGINEERS, LONDON.

Description on Page 97.)



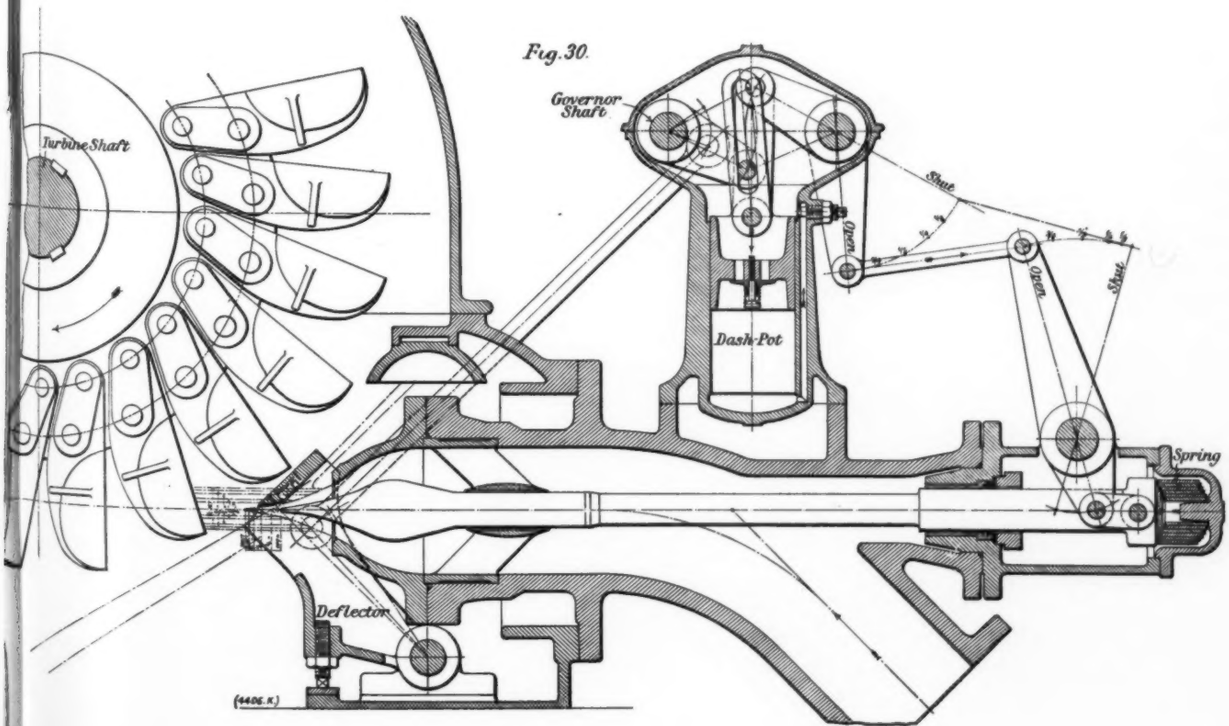


Fig. 30.

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

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NOTICES OF MEETINGS.

THE INSTITUTION OF CIVIL ENGINEERS: YORKSHIRE ASSOCIATION OF STUDENTS.—Friday, February 4, at 7.45 p.m., at the Cutlers' Hall, Sheffield, Mr. G. Martin Gamble, A.M.I. Mech. E., will read a paper entitled "Road Traction by Petrol, Steam, and Electric Motor Vehicles."

THE LONDON ASSOCIATION OF FORERMEN ENGINEERS.—Saturday, February 5, at 8 p.m., at the Cannon-Street Hotel, Cannon-street, E.C., Mr. Thomas Sugden, Wh. Sc., M.M.E., will give a lecture on "Superheated Steam." Any persons interested are cordially invited to attend.

THE SURVEYORS' INSTITUTION.—Monday, February 7, when a paper entitled "Dilapidations—Some Notes and Suggestions," will be read by Mr. C. F. Slater (Fellow). The chair will be taken at 5 o'clock instead of 8 o'clock.

THE ROYAL SOCIETY OF ARTS.—Monday, February 7, at 4.30 p.m. Fothergill Lecture. "National and Historic Buildings in the War Zone; Their Beauty and their Ruin," by the Rev. George Herbert West, D.D., A.R.I.B.A., author of "Gothic Architecture in England and France" (Lecture I.). Wednesday, February 9, at 4.30 p.m. "The Organisation of Scientific Research," by Professor J. A. Fleming, M.A., D.Sc., F.R.S. Mr. Dugald Clerk, D.Sc., F.R.S., Chairman of the Council, will preside.

THE SOCIETY OF ENGINEERS (INCORPORATED).—Monday, February 7, at 5.30 p.m., at Caxton Hall, Westminster, S.W. Mr. Norman Scorgie, M. Inst. C.E. (President, 1915), will present the Premiums awarded for papers read before the Society during the year 1915. Mr. Percy Griffith, M. Inst. C.E., F.G.S., F.R. San. I., the President for the year 1916, will then deliver his Presidential Address.

THE INSTITUTE OF MARINE ENGINEERS (INCORPORATED).—Tuesday, February 8, at 7 p.m, Adjourned discussion on "Power-Driven Tools on Board Ship."

THE INSTITUTION OF ELECTRICAL ENGINEERS: SCOTTISH LOCAL SECTION.—Tuesday, February 8, at 7 p.m., at the Princes-Street Station Hotel, Edinburgh. Paper: "The Principles of Modern Printing Telegraphy," by Mr. H. H. Harrison, Associate Member.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, February 8, at 5.30 p.m. Paper to be submitted for discussion: "Notes on the Working of a Rack Railway," by Mr. William Theodore Lucy, M. Inst. C.E.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—Wednesday, February 9, at 8 p.m., at the Royal Society of Arts, John-street, Adelphi, W.C., when Mr. W. D. Williamson will read a paper entitled "Petrol-Engines for Commercial Vehicles."

THE ASSOCIATION OF ENGINEERS-IN-CHARGE.—Wednesday, February 9, at 8 p.m., at St. Bride's Institute, Bride-lane, Fleet-street, E.C., a paper will be read by Mr. Wilfred Stokes, M. Inst. C.E., on "Multiple Effect: System of Refrigeration."

GLASGOW UNIVERSITY ENGINEERING SOCIETY.—Thursday, February 10, in the Physiology Department, The University, at 7.45 p.m. A lecture will be delivered by Mr. D. Burns, of that Department. The subject is "Man, Considered as a Machine."

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, February 10, at 8 p.m., "The Testing of Underground Cables with Continuous Current," by Mr. O. L. Record, Associate Member.

THE OPTICAL SOCIETY.—Thursday, February 10, at 8 p.m., in the Lecture Hall of the Chemical Society, Burlington House, Piccadilly, a lecture will be delivered on "Optical or Visual Signalling," by Dr. William J. Ettles, M.D., M.S., F.R.C.S., President.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, February 11, at 5.30 p.m., a discourse will be delivered by Professor W. M. Flinders Petrie, D.C.L., F.R.S. The subject is "Egyptian Jewellery." Professor Gilbert Murray, LL.D., is called away on Government duty. Afternoon lectures next week at 3 o'clock. Tuesday, February 8. Professor C. S. Sherrington, M.D., LL.D., D.Sc., F.R.S., Fullerian Professor of Physiology, R.I., on "Nerve Tone and Posture" (Lecture IV.). Thursday, February 10. Sir Frank Watson Dyson, M.A., LL.D., F.R.S., the Astronomer Royal, on "Measurement of the Brightness of Stars; Visual and Photographic Magnitudes" (Lecture I.). Saturday, February 12. Sir Sidney Lee, D.Litt., LL.D., on "The Shakespeare Tercentenary: Shakespeare as National Hero" (Lecture II.).

ENGINEERING.

FRIDAY, FEBRUARY 4, 1916.

RAILWAY ELECTRIFICATION IN THE UNITED KINGDOM.

NOT many years ago it was believed, or at any rate stated, by various enthusiasts—chiefly American — that Great Britain stood at the threshold of an era of extensive railway electrification. Some of the enthusiasts backed their belief in cash, and at least one large works was built and equipped to produce the material which it was supposed would be in demand. These pioneers were disappointed, and in the few years following the efflux of enthusiasm they and their proselytes spent some portion of their time dilating on the conservatism and lack of enterprise of the directors of English railway companies. These things are now in the past, and looking round, in the year 1916, one realises that after all perhaps our English railways have not done so badly. There has been no spectacular plunge after the manner of "God's own country," but, in our slow and cautious way, quite a respectable amount of work has been carried out. Speaking from memory, we think it correct to say that, of our great English railways, the Great Northern, the Great Eastern, and the South-Eastern are the only lines which have as yet done nothing in the way of electrifying any portion of their tracks.

The criticism which used to be current on this matter appeared always to overlook the very different conditions of the railways in the British Isles from those of the United States. Our railways led the world. In the long years between the classic trials at Rainhill and the present time they have multiplied from a length which might well be computed in yards, until they have mapped the country like the veins of a leaf, and have reached nearly every town which can fairly claim to be a town at all. So thoroughly has the work been done that a field which the electrical people might have expected to count as their own was occupied before their claim was made. We refer to the various connecting lines and branches running up into country districts from the main lines. The conditions of these branches are often such that they form suitable subjects for construction as glorified electric tramways under the Light Railways Act. That Act, however, and the electric manufacturers alike found that before they were in business almost all possible lines of this class had been constructed as heavy steam roads. There are some such electric light railways in existence, but they are few. The only one we can call to mind for the moment is the Burton and Ashby Light Railway, operated, we think, by the Midland Company. We do not suggest that it might not have been better had more railway branches of this class been constructed on different lines from what they were. They are by no means all successful. Many of them, built or purchased by the heavy lines as feeders, have turned out to be suckers. This, however, is no consolation to the electrical people. The railways are there, and the traffic they handle does not warrant the spending of further capital on them, especially with the motor vehicle more than a possible competitor.

The only likely sphere for electrical developments in the construction of new railways in this country lies in suburban work in the neighbourhood of large towns. This sphere is, however, not a large one, the ground here, as elsewhere, being mostly covered by steam roads which were in existence before multiple control was invented. Any consideration of the circumstances serves only to accentuate the fact that the major part of the electrification which can be done here must be in the conversion of existing railways, not in the construction of new ones. No doubt our enthusiasts will hasten to comment on this remark by saying that with bold and enterprising railway directorates we should have ten times the length of converted line we now have. This may be so; but there was an interesting table in Mr. Hobart's recent and admirable James Forrest lecture which may be brought in as evidence. According to Mr. Hobart's figures there were, in 1915, 45,000 miles of single track of electric railways in the United States and Canada; that is, of electric railways *per se*. In the same year there were 3460 miles of single track of electrified steam railway. This latter figure is less than 1 per cent. of the total single-track mileage of steam railways in the two countries.

In examining these figures it is fair to remark that the 45,000 miles includes many miles which in these islands would generally be described as "tramways." More properly, no doubt, they should be described as "light railways." By their proprietors they are described as "interurban railways." The point is that the Burton and Ashby Light Railway, and its like, which are in every way akin to them, are not, as a rule, included in computations of the total length of electric railway in this country. This makes our position appear relatively more backward than it is. We do not know that there is anything to prevent anyone describing the Burton and Ashby line as an interurban railway if they are so inclined. This point, however, may be allowed to pass; the main fact of Mr. Hobart's figures which we wish to emphasise is that less than 1 per cent of the total steam mileage of the United States and Canada has been electrified. We do not suggest that this figure should be larger. We do suggest, however, that if this is the proper proportion for the El Dorado of the electrical engineer, there cannot be much wrong with our own practice or the enterprise of our railway directors. Without working it out, we hazard the statement that more than 1 per cent. of the steam railway of this country has been, or is being, electrified. And, as we have tried to make clear, it is with the 3460 miles that our electrification must be compared. The conditions which have called the 45,000 miles into being have no counterpart here. The reason for this is, moreover, not only a matter of history. This very large figure owes something to the lack of enterprise of railway directors, other than British. Many of the electric railways of the United States have been built directly owing to

the very poor suburban and outer-suburban services offered by steam roads.

Although we contend that this country has quite a fair record in the matter of railway electrification as far as mileage goes, it is not possible to contend that all the apparently obvious spheres for this type of enterprise have been occupied. The major part of the work has, of course, been done around London, while two provincial cities have been favoured to the neglect of all the others. The two are Newcastle-on-Tyne and Liverpool, the latter place claiming no less than three electric railways. While it is easy to believe that the conditions in these two towns may have favoured electrification, it is difficult to believe that suitable spheres of operation might not have been found around some other of our great provincial cities. It would certainly appear that Birmingham, Glasgow, and Manchester might reasonably claim that it was their turn. Of Glasgow one has heard proposals in the past, but the war appears to have pushed them into the background; of Birmingham we know nothing as far as this subject is concerned; but in the case of Manchester an excellent start has been made by the scheme of the Lancashire and Yorkshire Railway which we have described during the last few weeks. This is a most notable addition to the electric railways of the country. While we have long thought the neighbourhood of Manchester a likely sphere for electric-railway enterprise, we must confess that in the early days we always pitched on the Manchester, South Junction, and Altrincham line, with that part of the Cheshire Lines Railways serving the beautiful country between Altrincham and Knutsford, as the most probable scene of the first experiment. Very evidently we were wrong, and while we still think the line a very suitable one for electrification, the matter would no doubt be rendered difficult owing to the complicated control under which both railways concerned are operated.

As it was left to the enterprise of the Lancashire and Yorkshire Railway to produce the fastest suburban service in the world, on its Liverpool and Southport line, so it has been left to the same company to operate the first electric railway in the Manchester district, a district which forms one of the greatest aggregates of population in the world. The description we have published shows that from the passengers' point of view the new line will closely resemble the Southport line. We know this line well, and can only say that the inhabitants of Manchester and Bury need ask for nothing better. An excellent and promising suburban district is tapped at Heaton Park and Prestwich, but beyond at Whitfield, Radcliffe, and Bury a different sort of country is encountered. This is Lancashire proper, and its inhabitants are not great travellers except once a year when they go to Blackpool.

From a technical point of view the new line is of much interest. It introduces a further electric railway system to this country, or rather it introduces an operating track voltage of 1200 to what may be called standard direct-current third-rail practice. If satisfactory operation can be secured, which is now proved, the advantage of 1200 volts over 600, in the saving of copper and of substations, is obvious. A good deal of work has, of course, been done, particularly in America, with voltages higher than 600, on direct-current railways. In some cases overhead conductors have been used, and in others third rails. As is generally known, before carrying out the work on the Manchester to Bury line, the Lancashire and Yorkshire Company made an experimental installation on the railway connecting Bury with Holcombe Brook. This employed overhead conductors and a trolley voltage of 3500 with direct current. The results of this experiment apparently did not justify the adoption of the system for the extensive electrification project in the Manchester district, of which the Bury line is the first instalment; the experience gained, however, had some influence in the determination to adopt a higher working voltage than 600.

We do not know the details of the considerations which led to the adoption of a third rail in preference to a trolley-wire for the new system. There is no doubt, however, but that a third rail will be quite satisfactory. The system has been used for higher voltages than 1200. It is also certain that a third rail will cost less than an overhead conductor, both for first cost and for upkeep. Engineers who favour an overhead construction state that the upkeep charges of a third rail are heavy, and that it is a great inconvenience at busy junctions. Mr. Aspinall has, however, said quite definitely that the experience of the Lancashire and Yorkshire Railway is that neither of these statements is justified. This experience is by now extensive, for not only has the original Liverpool and Southport line been working for a number of years, but the branch from Liverpool to Ormskirk has also been electrified, and has been working for some time. The main difficulty in the employment of a 1200-volt third rail in this country lies in the installation of the rail in such a manner that it shall not be a danger to platelayers. With voltages of this order in America it is usual to invert the rail, use an underrunning shoe, and entirely cover the upper parts of the rail with a protective cover. Unfortunately, owing to our loading gauge, this method is not applicable in this country. As already described and illustrated in our columns, Mr. Aspinall has got over the difficulty by devising a side running shoe, which allows adequate protection of the rail in a small space. The whole design is exceedingly neat and well worked out in its practical details. Altogether it opens a much wider prospect for electrification than there was before. The direct-current system has great advantages, but these are offset for long-distance work by its cost. The doubling of the voltage introduces a great economy, and relieves railway engineers from the necessity of entertaining the idea of introducing phase systems which will not work with existing plants. Mr. Aspinall's arrangement of protected third rail with side running shoe is mechanically only a small part of the whole equipment, but it is likely to prove a very important step in the electrification of our railways.

THE STANDARDISATION OF SHIP STABILITY CURVES.

All proposals having for their object the more ready application of scientific principles of ship design to definite cases are of interest to the naval architect, and if only for the reason that stability calculations are of a lengthy and somewhat tedious nature, and therefore all too infrequently undertaken, Mr. Wilfrid Ayre has done well to call attention to the subject in a paper read at the North-East Coast Institution of Engineers and Shipbuilders. The principal object of the paper, as stated by the author, is "to describe a method of standardising statical stability curves of form which is thought to be of value in designing vessels by providing reliable means to construct curves for various dimensions and conditions proposed without incurring the construction of body plans." "The second object of the paper is to illustrate the effect of systematically varying the proportion of beam and depth and of increase or decrease in the fulness or fineness of form." It is, however, to be feared that the very fact which Mr. Ayre deplores—viz., the disinclination to undertake lengthy stability calculations—will act as a serious bar to the adoption of his proposals, involving as they do twelve repetitions of this same calculation for the production of a set of standard curves.

The method proposed by the author, and illustrated by diagrams and a series of curves, is as follows:—A series of curves are calculated, at intervals of 15 deg., from 15 deg. to 75 deg. inclination, by means of the integrator for four sets of vessels whose block coefficients are respectively 0.5, 0.6, 0.7, and 0.8, and in each case the form of lines is proportionally developed to alter the ratio of beam to the depth H to 1.2, 1.6, and 2.0. Thus in all twelve complete body plans representing twelve vessels of parent varying form are systematically integrated, to show the effect of altering the ratio beam to H, in conjunction with varying fineness of form. In the calculations the position of centre of gravity is assumed at a point K on the centre line of ship at keel, the necessary correction for the actual position of centre of gravity being made at a later stage. In the series of curves shown the values of righting arm K Z, corresponding to three proportions of beam to depth, are plotted in the form of three cross curves, the numerical equivalents being expressed in terms of a coefficient C of the breadth of the ship to a constant abscissa scale of draught H, say 10 in. long. The depth value H is found by spreading out the buoyancy contained in the sheer, and in any erections whose buoyancy it may be deemed fit to include, over the length of the ship in such manner that a uniform depth all fore and aft obtains, and adding this to the moulded depth of vessel, thus obtaining the total average depth of the assumed water-tight structure. A simple formula for calculating the average depth addition for sheer and erections is given.

On the general question of the utility of standard stability curves it may be said that stability calculations are not considered necessary by the majority of designers where vessels are of normal proportions and where the conditions of lading throughout the voyage are not such as to call for special investigation. On the other hand, where the design is of an abnormal type or the proportions of vessel or conditions of lading are unusual, the stability for the whole range of conditions for this special type must be carefully investigated, and for this purpose standard curves deduced from normal types would not be trustworthy.

In view of the directness and simplicity of estimating the stability for moderate angles of inclination by means of the metacentric method, and the general acceptance of the reasonable stability for larger angles of inclination of normal ships designed and proportioned in accordance with the rules of the registration societies, it seems probable that the designer will continue, as heretofore, to confine his stability calculations to such types as present novel features likely to affect the stability.

The proposal to take account of the increase in buoyancy due to the immersion of deck erections in the form of a layer of equal volume added to the depth of the ship might be applied with confidence where the class of ship and the character of erections were similar, but erections are of such a varied character that it is easy to conceive of cases where the proposed form of treatment would give results showing righting levers in excess of those actually possessed by the ship. For this reason the designer would be inclined to regard doubtfully those parts of the curves which lie beyond the point where the deck edge becomes immersed, and the range of useful application of the standard curves would be thereby curtailed.

The second object of the paper is well brought out in the curves, and reference to those shown by the author well illustrate the effect on the righting lever of alterations in the ratio beam to depth and increase or decrease of fulness or fineness of form. The paper as a whole represents the results of a vast amount of labour on the part of Mr. Ayre, and is indicative of an earnest effort to make the investigation of the stability of proposed designs of varying form and proportions a simple process, such as can be readily applied in the earlier stages of design; but it is doubtful if the utility of the curves, when constructed, would repay the labour involved in their production.

A CHEMICAL INTELLIGENCE DEPARTMENT.

The question of instituting a Government Chemical Intelligence Department, which chemists have been discussing for some time, should not be dismissed simply for the reason that the British manufacturer regards official aid rather as interference than as a help. As presented by Dr. M. O. Forster, F.R.S., to the Society of Chemical Industry on two occasions, the suggestion of a Chemical Intelligence Department of the Board of Trade has threefold aims. The first are purely chemical and technical; the classification of chemical discoveries at home and abroad; dissemination of the information collected on processes, plants, apparatus, and scientific progress to scientists and manufacturers; tabulation of by-products and their utilisation; and presentation of problems for research. In pursuing the two other aims the Board of Trade would co-operate with the chemists and with the Board of Education for collecting information on the resources of the Empire; on foreign products, their distribution, transport facilities, and prices; and on opportunities for the training of chemists as well as of technical foremen. It certainly sounds tempting to hear of a department which would tell the inquirer where he could obtain his materials, apparatus, and men for working new promising processes, and where to dispose of his products. But could anything justifying the innovation—the creation of such a universal department—be realised at an expenditure such as the country would care to face at present?

That the Board of Trade is at present over-

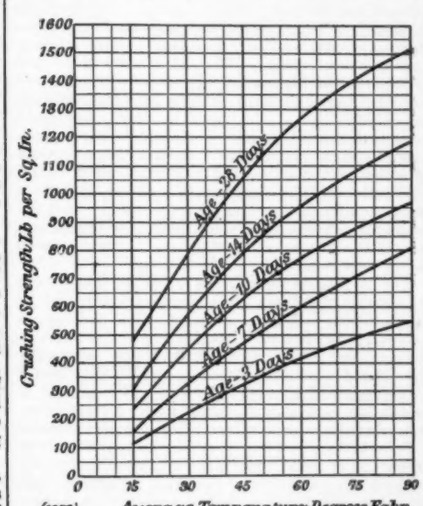
burdened with heavy duties does not much matter. A department of this kind would stand, more or less, by itself. Further, the Government does help the chemical and technical industries in general by publishing patent abstracts, and the consuls are expected to keep the Government and public informed as to the resources of other countries and their possibilities. Unfortunately, speakers complained, not without reason, at the meetings in question, that the British consul was not always competent and willing to answer inquiries. The same reproach of failing to distribute useful knowledge might be brought against the Press in general, and against the chemical Press, which has some excellent representatives certainly in the journals of the leading chemical societies, but lacks organisation, which the chemical industry lacks on the whole. The excuse is that the information, the Press asks for, is frequently withheld or limited, and not disinterested; the manufacturer pushes his own interest and does not like to take others into his confidence. There is hence the widespread suspicion that the information which the new department could disseminate might prove of questionable utility to the capable, energetic chemist, though it would be appreciated by the inexperienced man. Then consulting chemists may object to the scheme as impairing their interests. Mr. Gordon Salamon, moreover, was not wrong when he expressed the fear that the new department might become known as "the department for the synthetic production of red tape," unless the staff were renewed at intervals of a year or more, with the co-operation of the chemical societies. In no technical branch is there so much danger of getting out of touch with general progress as in the chemical industry, and the less a man—whether he be an official or an expert—feels at home in practical particulars, the more he is apt to insist upon what is styled "red tape." On the other hand, frequent changes would have their drawbacks, and they would certainly not simplify the question of remuneration. Many of the members of the various advisory committees now give their services free of charge—quite appropriately so, in times of stress. But these proposals concern normal times, and there is a decided and not unjustified prejudice against gratuitous, and hence irresponsible, advice, though cases of excellent honorary advisory services rendered will occur to everybody. On the other side, the mere thought of big consulting honoraria and retaining fees might kill any such scheme in the bud.

We should regret that. For the scheme of a Chemical Intelligence Department, whatever its final shape, and particularly the suggestion of expert members of Government Committees, temporarily appointed, and practically independent of the political machinery, well deserve consideration. If anything be achieved, it will probably be of a more general scope than what is proposed for the present. But nationalisation of the natural resources may come with time, and the relations of private to public interests should better be understood than they are now.

EFFECT OF TEMPERATURE ON THE STRENGTH OF CONCRETE.

ALTHOUGH it is of considerable importance to contractors for reinforced concrete structures and other concrete work to know when the forms may be removed and loads applied with safety, so much uncertainty exists on the matter that the time allowed between pouring the concrete and applying the load may be much in excess of actual requirements. This is undesirable for economic reasons; but, on the other hand, too early application of the load may cause a collapse, and thus lead to far more serious loss, so that no risks can be run. Any information which will assist engineers and others to decide how soon forms may be removed with safety should therefore be welcomed, and for this reason we wish to call attention to some experiments made by Mr. A. B. McDaniel in the Engineering Experiment Station of the University of Illinois.

These experiments were carried out in order to test the effect of temperature on the rate of increase in strength of green concrete. For this purpose over 150 specimens, in the form of cubes and cylinders, were made and stored at mean temperatures ranging from 26.5 deg. to 90.6 deg. Fahr., and tested after intervals of from three to twenty-eight days. The concrete used was composed of 1 part of "Universal" Portland cement with 2 parts of sand and 4 parts of crushed limestone, proportioned by weight, which corresponds to a proportion of 1:2.2:3.6 by volume. The average tensile strength of the cement used was 542 lb. and 609 lb. per sq. in. at seven and twenty-eight days respectively. Mixing was carefully done by hand, and the concrete was then moulded into the form either of 6-in. cubes, cylinders 6 in. in diameter and 6 in. long, or cylinders 8 in. in diameter and 16 in. long. Some of the specimens were moulded at the temperature at which they were to be stored, but most of them were moulded in the laboratory and taken to the storage-rooms after setting for six hours. In all cases the moulds were removed after two days, and the specimens were kept covered with layers of moist sacking, which was sprinkled daily. Most of the specimens were taken from their storage places, had their bearing surfaces coated with plaster, and were tested within an hour, but some were taken out of storage and kept in the laboratory for about twenty hours before testing. A spherical-seated bearing-block was used in the testing-machine. Before giving the results of the experiments it is necessary to mention that the figures obtained for the cubes and short cylinders were multiplied by 0.73 to make them comparable with the data obtained for



the long cylinders, the figure 0.73 being the ratio of the strength of prisms to strength of cubes determined by a committee of the American Concrete Institute.

Dealing first with the low-temperature tests, we may say the strength was found to increase slowly, but definitely, in specimens stored at temperatures near the freezing-point, either above or below it, provided they were not alternately frozen and thawed. Specimens subjected to this action showed the well-known disintegration effect, and were, as would be expected, weaker after 28 days than after 7 days. The crushing stresses obtained with specimens stored under these conditions were 410 lb., 470 lb. and 320 lb. per sq. in., at 7, 14 and 28 days respectively; the mean temperature of storage in this case was 27.1 deg. Fahr. Specimens stored at a mean temperature of 26.5 deg. Fahr., which never rose above freezing-point, gave stresses of 280 lb., 510 lb. and 680 lb. per sq. in. after the same intervals, and the corresponding figures for specimens stored at a mean temperature of 35.5 deg. Fahr., which never fell below freezing-point, were 340 lb., 800 lb. and 1130 lb. per sq. in. The stresses given are in all cases the mean values obtained for three specimens at each age and at each temperature of storage.

At ordinary, and at comparatively high, temperatures, higher stresses are reached in a given time, and, generally speaking, the stress seems to increase with the storage temperature, but the results obtained were not always consistent in this respect. The average stresses obtained with specimens stored at a mean temperature of 48.5 deg. Fahr. were 800 lb., 1130 lb. and 1410 lb. per sq. in. respectively, after 7, 14 and 28 days, while for a set stored at 72.8 deg. Fahr. the figures were 880 lb., 1210 lb. and 1530 lb. per sq. in. for the same periods. Another set stored at a mean temperature of 71.2 deg. Fahr., however, gave stresses in all cases lower than those stored at 48.5 deg. Fahr., the figures for the former temperature being 700 lb., 1040 lb. and 1380 lb. per sq. in. These figures, however, are the average results from only three specimens at each age, whereas those for the temperatures 48.5 deg. and 72 8 deg. are, in both cases, the average of five specimens, and should therefore be more reliable. At a mean temperature of 90.6 deg. Fahr. the stresses obtained after 7, 14 and 28 days were 790 lb., 1220 lb. and 1530 lb. per sq. in., which, it will be seen, do not differ materially from those stored at 72 8 deg., except at seven days, for which period the stress obtained at the higher temperature is the lower of the two.

As a result of these experiments, which include a number at other ages and temperatures than those quoted above, Mr. McDaniel concludes that for concrete hardening at from 60 deg. to 70 deg. Fahr., the ratios of the strengths at 7, 14, and 21 days to the strength at 28 days may be taken as about 0.5, 0.75, and 0.9 respectively. The ratios are higher for higher temperatures, and lower for lower temperatures, but there is not much difference for temperatures between 30 deg. and 70 deg. Fahr.; the values for the lower temperatures should, however, be used with caution. The actual strength of concrete after one week at a temperature of from 60 deg. to 70 deg. Fahr. would be practically double that of the same material kept at from 32 deg. to 40 deg. Fahr. The diagram annexed gives, with a fair degree of approximation, the strength attained by concrete of the class experimented on kept at any temperature between 15 deg. and 90 deg. Fahr. for periods ranging from 3 to 28 days, and this, we think, should form a very useful guide for determining the time when forms may be removed and loads applied.

NOTES.

PATENT, DESIGN, AND TRADE-MARK LITIGATION IN 1915.

A RECENT issue of the *Official Journal* (*Patents*) has, as is usual at this time, a supplement dealing with the cases reported of patent, design, and trade-mark actions. From this it is found that the total number of cases reported in 1915 is approximately of the same order as that in other years, although, on the whole, there has been a tendency for the number to decrease for the last few years. Thus in 1910 the number was 92; in 1911, 76; in 1912, 80; in 1913, 63; in 1914, 71; and in 1915, 62. The 1915 cases included 32 patent cases, 3 relating to designs, and 27 to trade mark, trade name, or passing-off actions. In connection with the patent cases, two patents were upheld, six held invalid (one appeal pending), three were revoked (one appeal pending), and three applications for revocation were refused. Although not deciding the validity of patents, several patent actions are of interest, such as the litigation in respect of the tungsten lamp, including the first application for a compulsory licence under Section 24 of the Patents and Designs Act, 1907, in which it was held that, even if the owners of the patent were unreasonable in the price they proposed to charge for drawn-tungsten wire as regards a single individual, their conduct would not be a failure to supply within the meaning of the Act, and no compulsory licence would be granted. Several actions have been brought in which decisions as regards alien enemies were necessary, and these have resulted in its being held that where, after a patent had been ordered to be revoked, war broke out between this country and that of the owners of the patents, and the owners of the patent appealed, they were entitled to be heard, notwithstanding that they were alien enemies. Again, where two companies joined in an action for infringement, but it was held that the patent had not been infringed by the defendants, and the plaintiffs appealed, and, owing to the outbreak of war, one of the appellant companies was an alien enemy, the appeal was suspended until after the conclusion of the war. Further, an appeal to the Privy Council from the Supreme Court of Australia, in an action for infringement in which the plaintiffs included alien enemies, was ordered to stand over, the point that the alien enemies were only bare trustees for the other plaintiffs being left open. Neither the design nor the trade-mark actions are of great interest from an engineering point of view, except perhaps one which dealt with winding machinery, in which it was held that a defendant

firm were entitled to make and advertise for sale universal machinery by the names "universal wind" or "universal machine," or "universal winding machinery," notwithstanding that the plaintiff firm practically claimed to have a monopoly of the term "universal winding machine." One case is of general interest—namely, that relating to the sale of brisling as Norwegian sardines, it being stated in Court by counsel that a trade of over a million pounds a year was involved.

Engine-Room Artificers.

The great increase in the Navy and the continuous sea service of every unit of the Fleet at exceptionally high speeds have made the demands upon the engineering *personnel* of the Fleet unprecedented in the history of the British Navy. It is true that there have been comparatively few actions, but in all of these the strategic and tactical advantage of speed has been an important element in the success. Moreover, the one certainty in our present crisis is the continuous full preparedness of all the ships, and only those who are cognisant of the many possibilities of breakdown or other disorganisation of machinery can realise what this means in the engine-rooms of high-speed vessels. Overhauls, as a rule, are carried out, in peace time, in the dockyards; but during war a great part of the important work is done by the staffs on boardship. The engineer officers have done splendid service for the nation, but they themselves will be the first to recognise that the engine-room artificer has proved not only ready and willing, but resourceful and untiring in such and all cases. We are glad to note that a generous word of praise has been spoken on a public occasion by Rear-Admiral Hutchinson on this subject. He instanced a case where the artificers on the ships of the Fleets succeeded in ten days in making good serious defects which had suddenly arisen, and which the engineer commander of the ship had told him would have taken six weeks to make good in the dockyard. This is but one of many instances which might be quoted were it prudent to do so. Unfortunately, it is not possible, officially or otherwise, to give details of the work done; but the information we possess encourages us to put forward a strong plea that the Board of Admiralty will not delay any possible recognition of the collective services of this rating in the Navy, and particularly of the individual services of any one member of the staff. Time and again we have had occasion to put forward the view that in promotions and in decorations for distinguished service the engineering branch of the Navy has not had its full quota, and we are disposed once more to enforce the same view. There have been one or two cases of special promotion of engine-room artificers to commissions, but when one remembers the great number of rankers in the army who have been promoted to be lieutenants, the number of naval rewards seems quite inadequate. We shrink from any odious comparison of the work in the trenches and the long and anxious vigils in the North Sea; but both are effective in the realisation of success. It could be shown, further, that artificers are doing the work of engineering officers; indeed, in some ships the *personnel* in the engine-room has been greatly altered since the outbreak of war, the proportion of officers to engine-room artificers being very much less; indeed, in some cases the latter preponderate to a great degree. There is, too, some element of injustice. We have in the Service to-day, working in corresponding positions, men who have passed through the same course of training, some for service in the merchant marine, where they continue, others for service also in the merchant marine, passing ultimately to the Navy as artificers. Now the former is of commission rank, the latter is still an artificer. This is, to a large extent, an inevitable condition; but it strengthens the view that when opportunity arises the artificer who has distinguished himself should be promoted to commission rank.

The Liverpool Salvage Association.—The Liverpool Association for the Protection of Commercial Interests as respects Wrecked and Damaged Property (the Liverpool Salvage Association) have appointed Mr. Harold Sumner, underwriter, Maritime Insurance Company, Limited, chairman of the Association for the year 1916, Mr. W. A. Edwards, secretary, Sea Insurance Company, Limited, senior deputy chairman, and Mr. F. R. Edwards, secretary, Reliance Marine Insurance Company, Limited, junior deputy chairman.

LITERATURE.

Aircraft in Warfare: The Dawn of the Fourth Arm. By F. W. Lanchester, M. Inst. C.E., M. Inst A.E. With Introductory Preface by Major-General Sir David Henderson, K.C.B., Director-General of Military Aeronautics. London: Constable and Co. [Price 12s. 6d. net.]

This work, treating a technical subject on which the public need both information and guidance, owes its origin to a series of papers contributed to these columns between September and December, 1914, and the series is reproduced here with but little alteration. The author states that revision has been confined to ordinary legitimate corrections, the original articles having been regarded and treated to all intents and purposes as a first proof. In this statement we think the author is rather too modest, for he might have urged that the articles have been revised in the light of greater knowledge and experience gained by constant contact with the work of development in aircraft itself, and perfected in the bitter school of actual warfare. Our readers will remember that the object of the contributions was twofold: first, to exhibit, at the date of writing, the position attained by the aeroplane and dirigible as weapons of offence and defence; and, secondly, to forecast the direction in which inevitable progress in construction, numbers, and mobility may modify military and naval strategy. Mr. Lanchester does not forsake any of his earlier expressed opinions, and here and there he gives reasons for strengthening his conclusions. We have in this convenient collection the advantage of studying many controversial points in the light of matured thought, and of weighing the argument as a consecutive whole. The outlook is not cheerful; it is shown that there is no finality in the struggle for mastery; that the scope for ruthlessness and violence is enlarged, and that in the future, as in the past, "the means to do ill deeds will make deeds ill done."

The author would impress upon us that we are witnessing the birth of a weapon calculated to revolutionise military strategy, and that it is necessary to exercise imagination—doubtless a trained and cautious imagination—in estimating the altered conditions of warfare which the general employment of aircraft will effect. He regards it as not less potent or significant than the introduction of artillery or cavalry. The use of the term "Fourth Arm" shows that Mr. Lanchester views aircraft as of equal importance in the equipment of a modern army as either of the three long-recognised branches, and foresees that in numbers the airmen may equal those of such a branch as the cavalry, about 6 per cent. of the entire fighting force. This view is traversed by Sir David Henderson, enjoying a position, as he reminds us, "strongly entrenched behind a barricade of military prejudice." Presumably this means that he represents the military or staff view, and that he does not share the enthusiasm of the inventor. Sir David points out that there is no sound basis for calculation, for determining the proportion of aircraft suitable for the requirements of an army. "To begin with, a single aeroplane absorbs, on the average, the services of some twelve officers and men, and its cost, which is not an immaterial factor, would provide more than a score of horses. The most accurate display of comparative figures will bring us no nearer a correct result. . . . The only safe line on which to proceed is to consider, first, what are the services which the aircraft are to be required to perform? second, how much of our available sources are we justified in devoting to these services?" Sir David might, too, have insisted on the short life of an aeroplane on active service. Three or four months' service fits them for the scrap-heap, and the manufacturing resources of the country must be capable of replacing the whole active force of aeroplanes three or four times over every year. It follows from this, that an army can never have a greater supply of aeroplanes than can be turned out by the country in three or four months. What this number may be we do not know, but apparently it limits some of the ambitious schemes the author invites us to consider.

Mr. Lanchester argues, on the other side, that if cavalry were as limited in numbers as the aircraft force, we should never have learnt the value of that arm, for cavalry would be negligible in action, and incapable of performing the functions for which they were organised. Further, that it is unwise to limit the possibilities of aeroplane service by the experience already obtained, or to conclude that its powers have been at all adequately measured by the effects reported. If numbers of machines are sufficiently increased, it would be possible, it is contended, to destroy a city like London, with its five millions of inhabitants, and, by disorganising the whole machinery for the management of national affairs, compel unqualified submission to the enemy. On the other hand, it is equally cogent to argue that with huge swarms of aeroplanes ably organised, a continuous and unrelenting attack might be maintained on every point of strategic importance behind the enemy's lines. Dépôts would be distroyed, bridges broken down, railways rendered impracticable, communications completely interrupted, and the country so laid waste that an impassable zone would exist in the enemy's rear, rendering his position precarious and compelling him to retreat from the lack of supplies. "Such a position of affairs presents all the elements conducive to complete and irreparable disaster."

Possibly none of the belligerents in the present war will secure such a complete mastery of the air as to enable him to pursue such tactics to a successful conclusion. We see only the commencement of enormous possibilities, and the future has to be reckoned with. If the lessons of this war are not duly learnt and turned to account, if the Government grow supine or are lulled by a benevolent optimism, if our authorities are not prepared to fight for aerial supremacy as strenuously in the future as they have for maritime supremacy in the past, a miserable fate may overtake us. Instructed intelligent opinion is necessary to urge the Government to fresh and constant endeavour, and to make the War Office authorities listen to the warnings of science. The value of Mr. Lanchester's book is that it is both interesting and informing, it appeals to the man in the street, it tends to the spread of correct judgment, it intimates progress on practicable lines. It is to be feared that much that has been written in some quarters has been sensational and unsound, creating a false enthusiasm whose hopes and ambition cannot be fulfilled. But here we have legitimate inquiry, both critical and hopeful, with limitations clearly defined and the lines of progressive development distinctly indicated. If to-day we hold our own against our redoubtable antagonist, whose technique is so well guided by pure science, accident has aided us as much as efficient preparation and considered design. Germany paid disproportionate attention to large dirigibles of the Zeppelin class, which as a military weapon have proved a failure. This does not say that the large dirigible will always be a negligible factor in determining the issue. It may be that its proper use has not yet been discovered, but that, when differently equipped, armed, and protected, it will prove a formidable weapon in competent hands. There is as much to be learnt from past errors as from successful accomplishment, but it is one of our national weaknesses to believe that we can always make up lost leeway, that personal capacity and individual daring will enable us to counteract the methodical, systematic progress that comes from steadfast training and a struggle to attain a uniform, high standard. We trust the author is not appealing to deaf ears when he says: "Let us not delude ourselves by supposing that the enemy will be content to allow us to retain our advantage without a keenly-contested struggle; he is probably ere this fully alive to his past mistake, and will strain every nerve to rectify matters."

How are we going to meet the resourceful and organised enemy? How are we to set up a machinery that will ensure effective experiment, a continuous policy, and sufficiency of construction in face of that uninstructed, but well-meaning, outcry for economical expenditure that is sure to arise. Mr. Lanchester is ready with a suggestion, that we trust will be considered when the necessity for immediate and rapid output is passed. It would be unwise to allow the temporary combination of skill, technical and theoretical; energy and initiative; craftsmanship with the use of material resources, to be scattered and lost. United, this combination has given us a lead in aeronautical science; but deprived of mutual assistance, lethargy or retrogression would supervene. The author's remedy is the formation of a Board of Aeronautical Construction that would acquire and control the manufacturing resources of the Royal Aircraft Factory. This Board would embrace responsible

officials of both the War Office and Admiralty, armed with sufficient authority to overrule the Treasury, and entrusted with powers to initiate any departure in advance of immediate requirements. The duties of such a Board would include the direction of the anti-aircraft equipment, the defence of the Realm, and have under its control all that pertains to aerial attack. The field of operations in the air is as large and important as on sea or land, and the plan that suggests the appointment of a Board having powers coequal with those exercised by the War Office or the Admiralty has much to recommend it. But it seems too much to hope that it will come into operation within a reasonable time. It is too thorough and sudden a departure from old traditions; there is not sufficient compromise or adaptation to existing methods to obtain at once the support of timid politicians.

Those who read Mr. Lanchester's illuminating articles as they appeared do not need to be reminded how completely he disclosed the purpose of various aircraft as fighting or reconnaissance machines, revealed the weak points or limitations that had been discovered in their construction, and indicated the direction in which improvements were possible. Those who have not enjoyed this advantage, and wish for authoritative guidance on many vexed and controversial questions, and are anxious to penetrate into a technical subject a little more deeply than is possible in an average newspaper article, will do well to read this volume. Similarly, others who want reasoned support for their hopes or sound warrant for the removal of besetting doubts, will be glad of trustworthy information. It must not be supposed that the author is able, or wishes, to settle all questions, and to decide the many issues that are raised from day to day. The whole problem bristles with controversial points. But there are limits within which useful controversy can be narrowed, and those who do not wish to talk nonsense, or would detect the fallacy of those who do, have got to know those limits and their influence. In this matter Mr. Lanchester will be found an excellent guide, writing with lucidity, and translating into ordinary language the results of those technical and scientific discussions that have contributed in no small measure to the production of aircraft of unquestioned merit. The novice may follow the strategic and technical uses of the aeronautical arm, be led to appreciate the importance of relative vulnerability, and gain an insight into the difficulties of armour and armament. He may gather through unequivocal mathematical argument additional grounds for trusting the basic principle of concentration of force, or perceive more clearly the importance of rapidity of fire. The theory of ballistics will assume new and interesting forms, and the difficulties and excitement of bomb-dropping will be more correctly estimated. The part played by aircraft in the Navy is not neglected. The tyro will learn the kind of service that aircraft can render to naval reconnaissance, and he can imagine a contest between aeroplane and submarine. If the destructive powers of the latter have been curtailed and brought within moderate limits, we imagine the aeroplane has contributed in no small measure to that happy result, and suspect that the author's discretion has prevented him revealing much that would have proved of the deepest interest. In many ways the author excites curiosity without satisfying it; this is inevitable in treating of new developments.

BOOKS RECEIVED.

The Canada Year-Book, 1914. Published by authority of the Hon. Sir GEORGE E. FOSTER, K.C.M.G., M.P., Minister of Trade and Commerce. Ottawa: J. de L. Taché. [Price 1 dol.]

Whitaker's Almanack, 1916. By JOSEPH WHITAKER. London: 12, Warwick-lane. [Price 2s. 6d. net.]

Annuaire pour l'an 1916, publié par le Bureau des Longitudes. Paris: Gauthier-Villars et Cie. [Price 1 fr. 50 c. net.]

The "Practical Engineer" Pocket-Book and Diary for 1916. London: The Technical Publishing Company, Limited, Gough-square, E.C. [Price 1s. 10d. post free.]

The "Practical Engineer" Electrical Pocket-Book and Diary for 1916. London: The Technical Publishing Company, Limited, Gough-square, E.C. [Price 1s. 10d. post free.]

The Electrical Engineer's Diary, 1916. *For the Use of Consulting Engineers, Architects, Electrical Contractors, Central Station Engineers, and all Users of Electrical Apparatus.* Edited by J. H. JOHNSON, M.I.E.E. London: S. Davis and Co., 30, St. Swithin's-lane, E.C. [Price 3s. 6d.]

Carnegie Endowment for International Peace. Year-Book for 1915. Washington, D.C.: 2, Jackson-place.

BRITISH PATENT LAWS AND FUTURE GERMAN TRADE.

TO THE EDITOR OF ENGINEERING.

SIR,—During the past twenty-five years or thereby some of us have done our best, in season and out of season, by pamphlet, brochure, in Parliament, and by communications to the Press, to impress our legislators with the importance of putting our British patent system on a better footing for the benefit of British inventors and for the general progressive business of the Empire. Notwithstanding frequent revision of the Patent Law, we have only yet attained to an elementary form of qualified search, and have not yet succeeded in throwing off the burden of patent taxes, which still remain to the injury and discouragement of British invention and British trade.

The first revolution in our patent system was in 1883, when the late Right Hon. Joseph Chamberlain, M.P. (a business man), while President of the Board of Trade, framed and carried the Patents, Designs, and Trade Marks Act, 1883, which, although an immense improvement on the old Act of 1852, had many serious faults, such as the continuation of the heavy renewal fees, though payable in a different way, too short a period for the duration of the patent, and failure to provide any form of search, with the consequent absence of any certainty of protection to the inventor. Passing over the amending Acts of 1884, 1886, 1888, 1901, and 1902, of minor importance, a second revolution was effected, or promised, by the much-belauded Patent Act of 1907, formulated and carried by the Right Hon. D. Lloyd George, M.P. (a lawyer), President of the Board of Trade. The success of this Act is still to seek.

If the Act of 1883 was revolutionary in one sense, the Lloyd George Act of 1907 was even more revolutionary in quite another and more harmful sense, and undoubtedly it is to the practical ignorance displayed in the framing of the Act of 1907 and its ridiculous provisions that most of our present patent grievances (and especially as regards Germans) have arisen. Hitherto all the previous British Patent Acts, but that of 1907, had the redeeming quality of catholicity in their not insisting on the working in this country of a British patent granted to a foreigner, and in this broad-minded and non-parochial sense they corresponded with the patent system in vogue in the United States, which system has proved so successful in comparison with the systems of all other countries.

Why Mr. Lloyd George should have followed the lead of an autocratic country like Germany in this sense, instead of that of a progressive nationality like the United States, has always been somewhat of a mystery, more especially seeing that the very precautions he apparently took to keep down German competition actually were the means of bringing, if not inviting, numbers of Germans over to Great Britain, ostensibly for the working of British patents granted to Germans, but practically to act as spies, as, since the war, we have discovered to our cost.

Arising out of these provisions in the Act of 1907 (as quite natural to Germans), the Germans quickly adopted reprisals against British owners of patents in Germany, bringing into force additional provisions for compulsionary working in Germany, and at the same time making it actually almost futile for British inventors to seek patents in Germany, while Americans applying for patents in Germany obtained special privileges because of the freedom from obligation to work patents granted in America to foreign owners of United States patents.

The Act of 1907, with the Act of 1914 and Rules made thereunder—after the war had begun—are responsible for the following present grievances:—

1. The Comptroller of the British Patent Office has not apparently the power to refuse acceptance of any application for a British patent, even although a patent for the identical invention may have been granted and published years before in a foreign country. Any British inventor prejudiced by the issue of the patent must simply accept the situation, his only recourse being to institute revocation proceedings in Court after the invalid British patent has been sealed.

The International Convention allows only a term of twelve months for filing a British application for an invention patented abroad; and no British inventor under the same Convention Rules has more than twelve months in which to file a foreign application for his invention patented in this country.

2. Any German desiring to appropriate a British invention for which a British patent has been granted to a British inventor may do so in the following circumstances:—

Supposing the British inventor applies within twelve months for a patent in Germany for his invention, his application may be successfully opposed there on one ground or another, and a decision issued in circumstances such that the British applicant cannot secure a hearing. In the case of an opposition to a British application of a German subject, proceedings are postponed to the end of the war. These privileges to foreigners are absolutely one-sided, so far as the ending of the war goes, though the foreigner's accepted British application cannot be sealed till the end of the war.

3. Under the 1907 Patent Act, anything known or unknown for which a patent is applied in this country, however impracticable (for which a British patent specification has not been filed in the British Patent Office Library during fifty years before the date of application), is entitled to British patent protection; fifty-one years' anticipation does not count.

These cases are not in any way hypothetical, but are taken from examples at the present time in actual existence.

After the passing of the 1883 Act of Parliament, there were great expectations that the result would be an increase in the number of applications for patents, and these expectations were fully justified, as in 1884, when the new Act came into force, the number of applications had increased by nearly three times the number in the previous year; while by 1889, or after six years, the patent applications had increased by nearly four times, and by 1897 the number had reached something like 31,000, or over 500 per cent. more than the applications in 1883 under the old Act. This number has practically been the high-water mark ever since. Certainly the 1907 Act, so much boomed by its author and the Press at the time of its introduction, has most lamentably failed to increase progressively, as expected, the number of applications for letters patent.

It is satisfactory to note that in "The Death-Knell of German Trade" debate, which took place in the House of Commons on January 10, Mr. Runciman, President of the Board of Trade, who controls the British Patent Office, pledged himself in the following words:—"I also agree that we must overhaul once more our Patent system and our Copyright laws"; which, however, is only a paraphrase of what his predecessor at the Board of Trade, the Right Hon. Mr. Ritchie, M.P., stated before the Associated Chambers of Commerce in 1900, nearly sixteen years ago, so that it may still be necessary to keep our new President of the Board of Trade this time strictly to his pledge.

In the same great speech, Mr. Runciman further said: "During the war we should do everything to destroy German credit, and to that end we should do everything in our power to cripple, cramp, squeeze, and destroy her trade (cheers). We must at the same time lay the foundations for future action, but we have been doing a great deal to destroy both her credit and her trade.

"We must see to it that, having ended this war victoriously, we do not give Germany a chance of reconstructing her commercial position. One of the first necessities of this country, if she is to hold her own during times of war and when war is over, is that we must improve our research methods."

These are brave and strong words to come from the President of the Board of Trade; but, to show earnestness, the first thing to be done should be the immediate scrapping of all rules so generously arranged by our Government for the benefit of the Germans since the war started. Invention, which is the life and soul of progress to any nation, should be welcomed and encouraged as, unfortunately, it is not under our present patent procedure; and, in the overhauling again of our patent system (foreshadowed by Mr. Runciman) there should, amongst other things, be included:—

1. A real search, to ensure novelty and validity, before any application for patent be entertained.
2. No patent to be granted unless novel or practicable.
3. The entire abolition of all renewal fees, as in the United States.
4. The extension of the period for each patent from 14 to 17 years, as in the United States.
5. Some form of guarantee for a *bond fide* inventor.
6. Simplified Court procedure in patent cases, so as to limit the frightful expense of patent litigation.

In the formulation of any new Patent Act, inventors, engineers, and business men should be called into consultation more than patent counsel, lawyers, and patent agents, as has hitherto been the case. Then, with the indispensable Minister of Commerce or Industry so long rightly clamoured for by the Chambers of Commerce and other representative bodies throughout the United Kingdom, and, these moderate advantages enumerated, Great Britain, after the war, would be brought into something like line with the United States, its principal future competitor in the world's trade, and so have every chance of holding its own.

The policy of Germany at the present time appears to be to uphold at any cost its present trade and its future outside commerce in this and in every other country. So far, therefore, as Germany and Austria are concerned, "*laissez-faire* policy" must go by the board, and Teutonic trade and business of all kind must be absolutely "barred" for, at any rate, all our time.

Yours truly,

JAMES KEITH,
Assoc. M. Inst. C.E., M.I. Mech. E., M.I. Mar. E.

Dunottar, Brondesbury, N.W.

"THE FLOW OF AIR THROUGH NOZZLES."

TO THE EDITOR OF ENGINEERING.

SIR,—In your report of the meeting of the Institution of Mechanical Engineers at which my paper on "The Flow of Air Through Nozzles" was discussed, I am quoted (in the third column of page 73 of your issue of January 28) as stating that "experiments made with the pressure tube gave but little evidence in favour of the jet having a parabolic form." This is a misapprehension. My experiments did point to the jet being parabolic in form.

On page 74, about the middle of the first column, the additional weight on the scale-pan which affected the sensitiveness of the balance in Mr. Brown's experiments is referred to as that of the nozzle. It was, of course, not the nozzle, but the cage which added the extra weight.

Yours sincerely,

THOS. B. MORLEY.

38, Westbourne-road, Sheffield, January 29, 1916.

"THE RUSSIAN CHAMBER OF COMMERCE IN LONDON."—The Foreign Office desire us to state that the organisation styled "The Russian Chamber of Commerce in London" has not obtained the recognition or approval of either His Majesty's Government or the Imperial Russian Government.

THE WORLD'S MERCHANT SHIPBUILDING IN 1915.

Not only have the demands of the navies of all belligerent Powers greatly interfered with the work of building merchant ships, but difficulty has been experienced in getting from the respective builders returns showing the work actually done; consequently we made no attempt to publish our annual review of the industry. Lloyd's Register, however, with its great staff of surveyors in all parts of the world, do not experience any difficulty in ascertaining exactly the extent of work done. But even in the case of Lloyd's Register it has been found impossible to get any information from the shipbuilders in enemy countries, so that their return of the world's work is in this respect incomplete. The abnormal conditions prevailing make it imprudent to institute strict comparison of merchant shipbuilding now with that of normal years. It is important, however, from the point of view of sea transport in the immediate future, to note that the output of merchant ships throughout the world is little more than one-third that of the average of the three or four years immediately preceding the war, as will be seen from Table II., which we take from Lloyd's Register, just issued.

Much has been said about the opportunity which has been given to neutral maritime countries for the development of their shipbuilding trade, consequent upon the absorption of the great majority of shipyards in the belligerent countries by the naval authorities for the augmentation of the sea fighting force. But it is noteworthy that in the case of Denmark the increase in output in 1915, as compared with two years ago, is only 4266 tons, equal to about 10½ per cent.; in the case of Holland, 8779 tons, or 7.9 per cent.; Norway, 11,433 tons, or 22.2 per cent.; Sweden, 1795 tons, or 9.7 per cent.; while in the case of the United States there has been a very considerable decrease, due, no doubt, to the absorption of workers for armaments for the European countries. It is true that there has lately been a great demand upon these neutral countries for new shipping, and that the result will not be obvious in the returns of production until next year. But withal we are not of those who take the view that the present extraordinary conditions will result in any great change in our dominating position amongst the shipbuilding countries of the world, provided that the workers in our shipbuilding and marine engineering works recognise their part in the re-establishment of the merchant shipbuilding industry after the war. As it stands, we have contributed about half the total merchant output of the world during the past year of warfare; and, although in previous years our proportion has been as high as 60 per cent., the situation must be regarded as satisfactory for the present and reassuring for the future.

Lloyd's figures only include vessels intended for merchant purposes; that is to say, ships of the mercantile type may have been built as auxiliaries for the Navy, but these are not reckoned in their return. The vessels included number 327, of 650,919 tons (excluding vessels of less than 100 tons), as compared with 656 vessels, of 1,683,553 tons, in 1914, when we had had seven months of peace, and with 88 vessels, of 1,932,153 tons—the highest ever reached in the history of the industry—during 1913. Of the total vessels launched last year, 317, of 648 629 tons, were steamers, and 10, of 2290 tons, sailing vessels, barges or similar craft. Of the total, 85½ per cent. were for British owners, the remainder, totalling 96,116 tons, being for foreign account. This latter gives a proportion of 14½ per cent., as compared with an average of 22½ per cent. for the previous five years. As regards the class of vessels built, it may be said that the largest was of 13,400 tons, and two others were over 10,000 tons. Thirty-three of the vessels, equal to about 10 per cent., exceeded 6000 tons. The average size of the vessels was 2046 tons; but if steamers of less than 500 tons be excluded, the average reaches 3791 tons—considerably less than in the preceding five years. Six of the steamers, making 53,192 tons, were fitted with Parsons steam-turbines, all having gearing between the turbines and the propellers. Two vessels, together of 10,700 tons, were fitted with internal-combustion engines. Seven vessels, of 43,665 tons, were built on the Isherwood system of longitudinal framing, four of them, along with a fifth steamer (with ordinary transverse framing), being for the carriage of oil in bulk. Eight vessels, of 66,334 tons, had cruiser sterns, and of trawlers and other fishing craft 104 were built.

In Table I. there is set out the production in the various districts in the United Kingdom as classified by Lloyd's, showing the totals for the past three years. It will be seen that the decrease was general throughout the whole of the kingdom. At Glasgow the total is only about one-quarter that of 1913; at Greenock about one-third; at Belfast about one-fourth; while on the North-East Coast the proportions generally are about one-third. Of course, Lloyd's say nothing about warship work; but were this reckoned it would probably be found that, throughout the whole of the kingdom, the work for war purposes, either on ships or for munitions, has made the districts as busy as, if not more so than, in the most active period of the history of the industry.

In Table II. there is given the total output of all the countries in the world, but here again comparison is not justified, in view of the exceptional conditions prevailing. Outside of the United Kingdom the output has been 416 vessels, of 550,719 tons, 100,000 tons less than within the United Kingdom. Of the total, 313 were steamers, of 518,948 tons, and 103 sailing vessels, of 31,771 tons; the decrease as compared with 1914 is 53 per cent., and as compared with 1913 it is 850,000 tons. No figures are available for Germany, Austria-Hungary, or Belgium. Of the vessels built, 33 were of over 5000 tons, the largest, a collier built in the United States, being of about 11,000 tons. While we only built two ships propelled with internal-combustion engines, the total in other countries is eleven, exceeding 1000 tons, their aggregate tonnage being 42,000 tons. The Isherwood system is also being well supported in foreign countries, notably in America, where twelve steamers, of 71,467 tons, were constructed. The number of steamers with turbines was the same as in the United Kingdom—namely, six, of 35,000 tons; while of oil-carrying ships, other countries than Britain provided six, of 33,000 tons, five of them being constructed in the United States.

The tonnage launched in the United States is made up of a total of 177,460 tons, which is 23,302 tons less than that of the previous year. There were launched on the coast 13 sea-going steamers, of from 5000 to 7000 tons each, and one collier, of about 11,000 tons. The total tonnage (113,075 tons) launched in Holland during the past year is about 5000 tons less than the output of 1914, which was a record in the Society's returns for that country. This total does not include vessels known to be exclusively intended for river navigation, which appear from information to hand to amount to over 70,000 tons. The total output, including such craft, would appear to reach over 183,000 tons. The largest vessel launched during the year was of about 8000 tons. There are four other steamers of from 5000 to 7500 tons each. The returns from Norway show the output to be 62,070 tons, about 8000 tons more than the total for the previous year, and the highest ever recorded in the Society's returns for this country. As in other years, the tonnage launched is practically composed of vessels of between 1000 and 2000 tons. Only one vessel of a larger tonnage has been launched—viz., a motor vessel of 2600 tons. The tonnage launched in Japan during the year (49,408 tons) is over 42 per cent. lower than the output for 1914. It comprises two steamers of about 9500 tons each, and one steamer of 7375 tons, fitted with steam-turbine engines. The production in Denmark (45,198 tons) exceeds that for the previous year by nearly 13,000 tons, and is the highest on record. Included in this total are six

Table I.—*Number and Tonnage of Merchant Vessels Launched in the Principal Shipbuilding Districts of the United Kingdom during the Three Years* 1913-15.

District.	1915.		1914.		1913.	
	No.	Tons (Gross).	No.	Tons.	No.	Tons.
Aberdeen	33	7,103	47	10,190	38	11,148
Barrow, Maryport, and Workington	3	2,174	1	284	4	1,837
Belfast	8	33,729	21	239,819	15	129,081
Dundee	5	4,587	10	11,793	8	17,944
Glasgow	45	106,203	110	348,103	150	415,044
Greenock	28	98,870	51	196,518	64	269,743
Hartlepools and Whitby	13	59,303	29	124,419	33	153,071
Hull and Grimsby	65	24,018	93	53,726	88	49,682
Leith	10	5,889	17	18,671	17	18,901
Liverpool	8	10,672	15	39,465	16	34,404
Middlesbro' & Stockton	30	58,574	70	137,165	62	154,743
Newcastle	36	124,001	91	315,585	94	366,351
Sunderland	31	110,942	72	277,528	78	299,964

TABLE II.—TABLE SHOWING THE TONNAGE OF VESSELS OF 100 TONS GROSS AND UPWARDS (EXCLUDING WARSHIPS) LAUNCHED IN THE VARIOUS COUNTRIES OF THE WORLD DURING THE YEARS 1899-1915.

Year.	United Kingdom.	British Colonies.		Austria-Hungary.	Denmark.	France.	Germany.	Holland.	Italy.	Japan.	Norway.	Sweden.	United States.		Other Countries.	Totals.	
		—	Canadian Lake Ports.										Coast.	Great Lakes.			
	tons	tons	tons	tons	tons	tons	tons	tons	tons	tons	tons	tons	tons	tons	tons	No.	tons
1899	1,416,791	6,475	1,989	9,218	26,613	89,794	211,684	34,384	49,472	6,775	27,853	10,367	146,108	78,170	6,015	1269	2,121,738
1900	1,442,471	6,967	2,506	14,889	11,060	116,858	204,731	45,074	67,522	4,543	32,751	5,735	190,962	142,565	15,439	1364	2,304,163
1901	1,524,739	16,610	11,524	20,013	22,856	177,543	217,593	29,927	60,526	37,208	36,875	8,241	268,091	165,144	20,649	1538	2,617,539
1902	1,427,558	18,235	10,584	15,192	27,148	192,196	213,961	69,101	46,270	27,181	37,878	9,030	225,360	155,814	29,247	1650	2,502,755
1903	1,190,618	20 866	13,824	11,328	28,600	92,768	184,494	59,174	50,089	34,514	41,599	11,855	211,219	170,601	24,073	1650	2,145,631
1904	1,205,102	27,253	3,712	16,645	15,869	81,245	202,197	55,636	30,016	32,969	50,469	10,267	189,430	49,088	17,987	1643	1,987,935
1905	1,623,168	45—10,798		16,402	17,557	73,124	255,423	44,135	61,629	31,725	52,580	5,282	107,368	195,459	20,272	1576	2,514,922
1906	1,828,343	16,036	10,016	18,590	24,712	35,214	318,230	66,809	30,560	42,489	60,774	11,579	169,358	271,729	15,334	1836	2,919,763
1907	1,607,890	21,479	24,994	8,717	28,819	61,635	275,003	68,623	44,666	66,254	57,556	11,781	217,530	257,145	26,026	1788	2,778,088
1908	929,669	25,512	8,669	23,502	19,172	83,429	207,777	58,604	26,864	59,725	52,839	9,546	158,645	145,898	23,435	1405	1,833,286
1909	991,006	6,592	869	25,006	7,508	42,197	128,696	59,106	31,217	52,319	28,601	6,316	80,485	129,119	12,960	1063	1,602,057
1910	1,143,169	14,601	11,742	14,304	12,154	80,751	159,303	70,945	23,019	30,215	36,931	8,904	177,601	153,717	20,497	1277	1,957,853
1911	1,803,844	16,006	3,456	37,836	18,689	125,472	255,532	93,050	17,401	44,359	35,435	9,427	95,693	75,876	17,864	1599	2,650,140
1912	1,738,514	25,090	9,700	38,821	26,103	110,734	375,317	99,459	25,196	57,755	50,255	13,958	194,273	89,950	46,654	1719	2,901,769
1913	1,932,153	26,744	21,505	61,757	40,932	176,095	465,226	104,296	50,356	64,664	50,637	18,524	228,232	48,216	43,455	1750	3,332,882
1914	1,683,553	22,288	25,246	*34,335	32,815	114,052	*387,192	118,153	42,981	85,861	54,204	15,163	162,937	37,825	*36,148	1319	*2,852,753
1915	650,919	13,289	8,725	† —	45,198	25,402	† —	113,075	22,132	49,408	62,070	20,319	157,167	20,293	*13,641	743	*1,201,638

* Returns not complete. † No returns.

This table does not include particulars of vessels of less than 100 tons gross; and takes into account only vessels that were launched, whether they were completed during the year or were still under construction at the end of the year. On account of the war, it is impossible to give full figures for the whole of the years 1914 and 1915 in respect of several countries; for the same reason warship tonnage has been excluded throughout this summary.

Lloyd's Register, just issued.

Much has been said about the opportunity which has been given to neutral maritime countries for the development of their shipbuilding trade, consequent upon the absorption of the great majority of shipyards in the belligerent countries by the naval authorities for the augmentation of the sea fighting force. But it is noteworthy that in the case of Denmark the increase in output in 1915, as compared with two years ago, is

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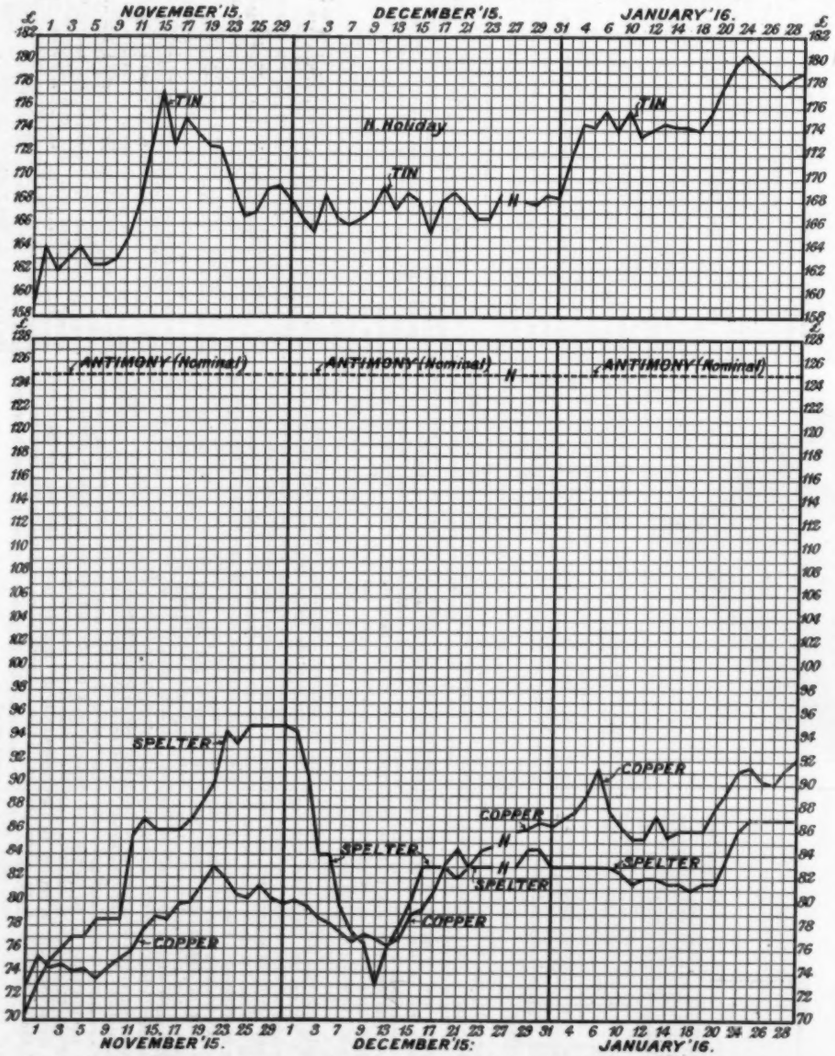
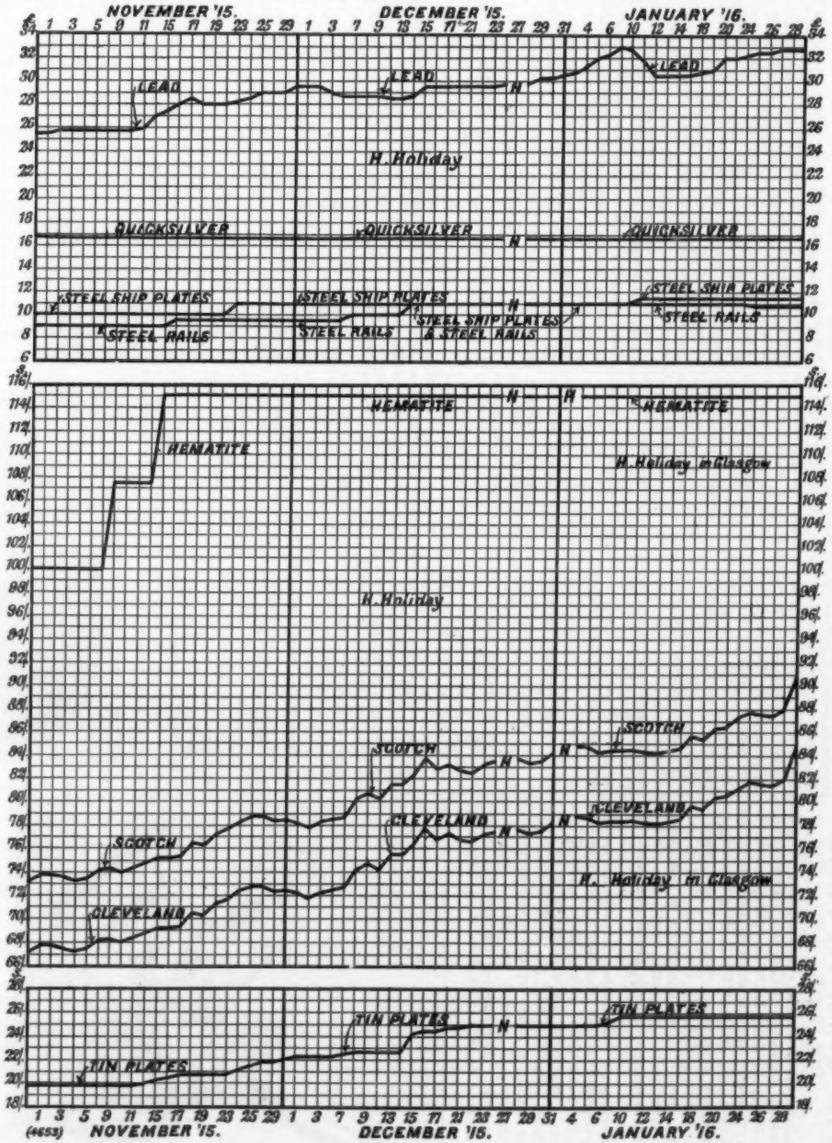
Australia's Navy: New Light Cruiser.—Australia's Navy is expanding. Recently the cruiser Brisbane was launched at Cockatoo Island, and in Navy orders issued in December last it is notified that a new light cruiser is about to be laid down where the Brisbane was built. This cruiser, when completed, will be named H.M.A.S. Adelaide.

The late Mr. Charles Alfred Trery.—We regret to have to announce the death, which occurred on January 28, at his residence, 84, Woodside, Wimbledon, of Mr. Charles Alfred Trery, civil engineer, late of Buenos Aires. Mr C. A. Trery was born on February 1, 1854. He was educated in the engineering profession, and, as a pupil of Mr. William Trery, he was engaged in civil engineering work in Sweden in 1872. In the following years, down to 1877, he was occupied in Portugal, on the survey and construction of the Minho District Railway, under Mr. William Trery and Mr. G. B. Bruce. He then engaged in private practice in Portugal down to the year 1881, when he drew up plans and estimates for the Regoa water supply, town hall and market for the Portuguese Government. From 1882 to 1887 he acted as sectional resident engineer on the surveys, location and construction of the Bahia and San Francisco Railway (Timbo Branch), Brazil, and on the same railway as resident engineer from 1887 to 1889, under Mr. R. Tiplady. In 1889 he was appointed resident engineer of the Bahia Blanca and North-Western Railway, at that time in construction (Argentine Republic). Mr. Trery read an interesting paper before the Institution of Civil Engineers last November, on the works at the Galvan Port, Bahia Blanca, an abstract of which we gave in our last volume on page 603. He was elected a member of that Institution in 1892.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially Compiled from Official Reports of London Metal and Scotch Pig-Iron Warrant Markets.)





NOTE.—In the diagrams on the present page the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for "fine foreign" and "standard" metal respectively. The prices plotted for antimony and lead are for English metal in both cases, while those for spelter are for American metal—the only kind at present available. Steel ship-plates and heavy steel rails are plotted to Middlesbrough quotations; the usual discounts are allowed in the case of ship-plates, but rails are net, free on board, at Middlesbrough. The figures plotted for hematite, Scotch and Cleveland irons are Glasgow settlement prices, and these prices are per ton, as are also those for all other metals previously mentioned. The price of quicksilver is, however, per bottle, the contents of which weigh about 80 lb., and the price of tin plates is per box of I.C. coke free on board at Welsh ports. Each vertical line in the diagram represents a market day, and the horizontal lines represent 1*l.* each in all cases, except those of hematite, Scotch and Cleveland irons and tin plates, where they represent 1*s.* each.

COMBINATION TOOL FOR CAPSTAN LATHES.

We illustrate below a useful combination tool, made by the Selson Engineering Company, Limited, of 85, Queen Victoria-street, E.C., for simultaneous recessing and facing operations on small capstan lathes. The tool is especially adapted for cutting the recesses at the back of the threads in "gaines" and No. 100 Graze fuze bodies and facing the front of the body at the same time. Other operations in the manufacture of fuzes, and other small parts, can also be conveniently and expeditiously performed with the tool.

The photographic illustration, Fig. 1, shows the general appearance of the tool, which consists of a mild-steel shank and body, with a slide carrying the cutting-tools. The slide has a cross-travel of ½ in., and is operated by a cam-lever, mounted on the body and bearing against a roller on the slide, as shown; this arrangement, of course, provides a sensitive feed for the tools. The internal construction of the tool is illustrated in Fig. 2, but as it is frequently

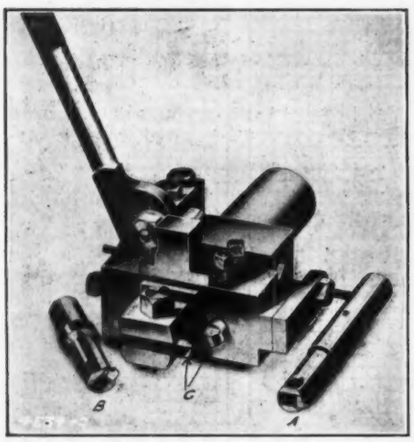


Fig. 1.

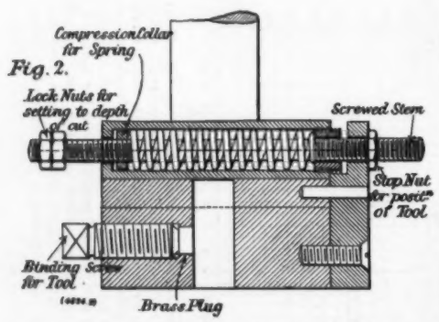

Compression Collar for Spring
Lock Nuts for setting to depth of cut
Screwed Stem
Stop Nut for posit^n of Tool
Binding Screw for Tool
Brass Plug

Fig. 2.

supplied for recessing only, the facing-tool has been omitted from the drawing. The recessing-tool is mounted in a holder, having a cylindrical shank, which is fixed by a set-screw, and when a facing-tool is used it is made from a rod of circular section, and held in place by two set-screws, as shown in Fig. 1.

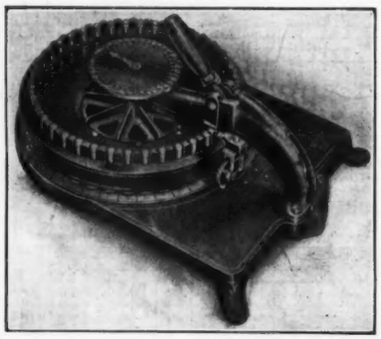
It will be seen from the drawing, Fig. 2, that the body contains a helical spring, which bears at the right-hand end on a plug, screwed into the body, and, at the other end, on a collar screwed on to a bolt, which passes completely through the body. The bolt also passes through a lug on the slide, and the lug bears against a stop-nut, so that when the slide is moved to the right, the spring is compressed, and by this means the slide is returned to its original position as soon as the lever is released. The travel of the slide is limited by a pair of lock-nuts, shown on the left-hand end of the bolt in Fig. 2, and these lock-nuts are adjusted to suit the required depth of cut. In operation the combination tool is mounted in the turret with its tool-holder in line with the hole in the work, the adjustment being effected by means of the stop-nut on the right-hand end of the bolt. The turret-slide is then brought forward to a stop, and the cutter is fed into the work by the lever as far as the lock-nuts will permit. When this point is reached, the lever is released, to allow the tool to return to its original position, and the turret slide is then brought back.

As illustrated in Fig. 1, the tool is arranged for recessing the internal thread in the base of the No. 100 fuze body and simultaneously facing the end, these operations being performed by the cutters lettered C. The hole is, in this case, large enough to clear a tool-holder of the form illustrated. For recessing the backs of the threads in smaller holes a tool of the type lettered B is employed, this tool being used in the screwed hole in the front end of the No. 100 fuze body. The tool lettered A, which, it will be noticed, has two cutters, was designed for recessing simultaneously two internal threads of different diameters in "gaines," but the design of the latter has now been altered, so that this tool is no longer used. The combination tool is, of course, quite suitable for external recessing work, and, by employing a former in the tool-post on the cross-slide of the lathe, it can also be used for taper boring.

STENCIL-CUTTING MACHINE.

The accompanying illustration shows a machine, known as the "Diagraph," which is used for cutting stencils in a special kind of oiled paper. With this machine complete names and addresses can be cut in a single sheet of paper in about two minutes, which is, of course, very much less than the time required to select the necessary letters from a set of metal stencils. The cost of a paper stencil would be less than 1d., and each stencil, we are informed, can be used over 1000 times if a special brush with long, soft bristles, supplied with the machine, is used for inking; they are therefore much more economical than similar stencils specially cut in zinc. The paper stencils can be used for marking drawings, ammunition boxes, packing-cases, steelwork, or any other stencilling work, and their flexibility is an obvious advantage for marking goods with curved or irregular surfaces. The machine might also be employed for cutting the wording of advertisements on lamp-shades now largely used in shops and public vehicles on account of the lighting restrictions.

As will be gathered from the illustration, the machine comprises a cast-iron base-plate, on which is mounted a vertical spindle, supported at its upper end



by a curved arm. The spindle carries a wheel, and around the periphery of this wheel the punches and dies for cutting the letters, numerals, and punctuation marks are mounted. These punches and dies, the makers state, are designed so as to be self-sharpening, and they can be changed in a few moments, as they are only held in place by a couple of screws. To use the machine, the oiled paper is placed with its front edge on the first of a series of guide-lines on the bed-plate, and passed between two pairs of knurled feeding rollers, one of which can be seen under the curved arm; the other pair of rollers are under the base-plate, and these are lowered to admit the paper by means of a small lever, just distinguishable in the centre of the front edge of the base-plate. When this small lever is released, the paper, the back edge of which comes between the punches and dies, is firmly clamped by the feed-rollers. The wheel is then turned by hand until a pointer, travelling over a stationary dial, comes opposite the letter required, and the punch is forced through the paper by pulling forward the handle mounted on the curved arm, and clearly visible in the illustration. On releasing the handle, the punch is forced up clear of the paper by a spring. During the first part of the movement of the handle the paper is fed forward one space by means of a ratchet mechanism which rotates the upper pair of feed rollers, and if it is required to form a space without cutting a letter, the handle is brought up to the vertical position, and released; whereas in cutting a letter it must be pulled forward as far as possible. Proceeding in this way, a line of lettering of any length may be cut, and when the line is completed, the feed-rollers are released, and the paper shifted backwards, so that its front edge lies on the second guide-line. Another line of lettering is then cut, and so on, until the required number of lines have been completed.

The machines, which are sold in this country by Messrs. Herbert E. Williams and Co., of 47, Lime-street, London, E.C., are made in three sizes, to cut letters ½ in., ⅞ in., and 1¼ in. deep, respectively. Our illustration shows the smallest size, of which the total weight is about 80 lb., and the base-plate measures 2 ft. by 1 ft. 6 in. This machine cuts six-line stencils, while the two larger sizes cut four-line and three-line stencils respectively. The width of paper used cannot, of course, exceed the semi-diameter of the wheel; but if more lines are required than can be cut in one operation, the work can be continued on another sheet of paper. A very handy form of reservoir brush forms part of the outfit supplied with these machines. The reservoir, which forms the handle, is filled with a suitable liquid ink, and when the brush is shaken so as to release a small spring-controlled valve, a quantity of ink runs down into the bristles. The device saves much time, and is obviously a great improvement on the brush and cake of solid ink usually employed for stencilling.

SYNDICATES IN THE GERMAN IRON TRADE.

The German Bar-Iron Export Union has been formed on account of the excellent results which the industry has derived from the Heavy-Plate Union in preventing plates being sold at absurdly low prices to the neutral foreign countries. The works now obtain prices which are as much as 60 marks above the home prices, although at present foreign buyers save two-thirds of this extra price on account of the highly unfavourable rate of exchange. The Export Union for Heavy Plates has recently been supplemented by the creation of an Inland Union. The Shipbuilding Steel Bureau is still in existence, but its action is confined to inland trade. It has caused some surprise that there has been no union for the thin-plate works; but the experience of the last Thin-Plate Union was not satisfactory.

As far as the Bar-Iron Union is concerned, only two firms of any magnitude appear to have kept aloof—viz., the German-Luxemburg Mining and Iron Works Company, and the Königin Marie Hütte, at Cainsdorp. The combine, however, comprises about 95 per cent. of the aggregate production, which means an almost complete control over the deliveries. The object, amongst others, is to prevent German products getting through to the hostile countries, and it has been repeatedly asserted that attempts have been made from such countries to obtain certain German manufactures from the heavy-iron industry. It must be remembered in this connection that before the war such export took place on a considerable scale.

In the meantime an embargo has been put on the export and transit of girders, shape iron, bar iron, and hoop iron (which latter article is also to be regulated by the Bar-Iron Union). It is, however, generally believed that the embargo is not meant to put a complete stop to the export of bar iron and the other articles referred to, the more so as the German industry is reported as being quite capable of both providing the necessary raw material for her military and other requirements, and at the same time keeping up her former trade with those foreign countries which still deal with Germany. As a result of the recent movements in the above-mentioned branches, German manufacturers of bar iron, girders, hoop iron, &c., have informed their customers in the neutral countries—or, at least, in one neutral country—that the current contracts for these commodities must be considered as cancelled, and that new contracts would have to be entered upon at an increase in price of probably about 75 per cent. The new arrangement is to take effect immediately, and may even be extended to goods already on their way. A prospect is held forth of the old contracts again coming into force when quieter and more normal conditions have again come about.

Carbon in Cast Iron.—At a meeting of the Ipswich Engineering Society, held at the Museum, on Thursday evening, January 20, Mr. E. Adamson, of Sheffield, read a paper on "Carbon in Cast Iron." He said that for many years it was commonly understood that the highest amount of carbon that could be taken up by pure iron was 4¼ per cent. At 1100 deg. Cent. that figure was correct, but on raising the temperature to 2200 deg. Cent. it was found that 9½ per cent. of carbon could be absorbed. Iron containing 4½ per cent. of carbon, when cooled down under normal conditions, made white iron; but with the higher percentage it was impossible to secure a white iron, because a certain amount of graphite separated out, and consequently made it grey or mottled. Above a temperature of 2200 deg. Cent. the iron would not contain so much as 9½ per cent. of carbon, because a certain amount of the carbon was really burnt out. The most important point was the time during which the iron was left in contact with the hot coke in a foundry cupola, and also the temperature of melting, as this decided the total amount of carbon taken up, and accounted for the differences in modern iron from those of the cold blast manufacture. On re-melting pig or cast iron the lecturer showed how important was the primary condition of the carbon in influencing the grade and strength of the material produced. The quicker the cooling the more closely compacted was the form of the carbon, and therefore the greater the strength and durability of the metal. Analysis alone would give only a rough-and-ready guide as to what character the cast iron would be, but the fracture showed whether the casting would be close or open.

ELECTRICAL RAILWAYS.*

By HENRY METCALF HOBART, M. Inst. C.E.

(*Concluded from page* 91.)

RATIO OF TON MILEAGE TO TRAIN-MILEAGE OF FREIGHT TRAFFIC.

Mr. James J. Hill has stated that "the place for the railroads to save in is their train-miles." *The Annalist* for September 6, 1915, gives statistics which bring out very clearly the extent of the practical application of this maxim to American railroads during recent years. The statistics quoted by *The Annalist* are plotted in Figs. 16 to 20. From Figs. 16 and 17 we see that for two specific cases, the Chicago, Burlington and Quincy Railway, and the Wabash Railway, while the total annual train-mileage of freight traffic during the last fourteen years shows no marked change, decreasing 11.1 per cent. for the first-mentioned railway, and increasing 17.5 per cent. for the last-mentioned railway, the total annual ton-mileage has in these fourteen years increased respectively in the two cases by no less than 127 per cent. and 75 per cent. Figs. 18 and 19 relate to the results for the entire railway system of the United States, and show that corresponding to an increase of only 22 per cent. in the annual train-mileage of freight traffic during the fourteen years there has been an increase of 104 per cent. in the annual tonnage of freight traffic. Finally, in Fig. 20 are plotted, for the three cases, the ratio of the ton-mileage to the train-mileage for the annual freight traffic during the last fourteen years, and the following results are given:

Fig. 16.

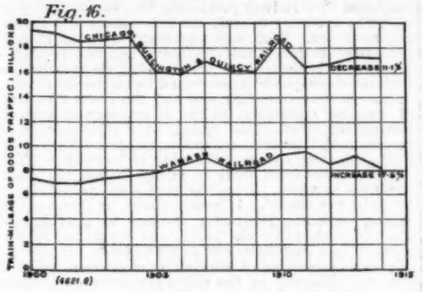


FIG. 16. ANNUAL GOODS TRAIN-MILEAGE ON TWO AMERICAN RAILWAYS.

Fig. 17.

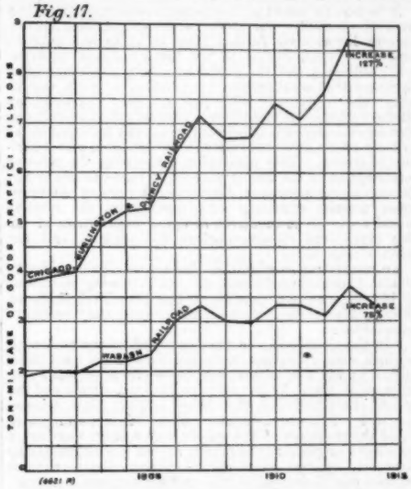


FIG. 17. ANNUAL GOODS TON-MILEAGE ON TWO AMERICAN RAILWAYS.

Fig. 18.

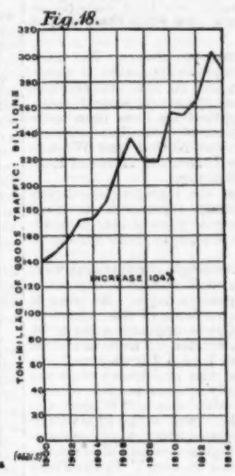


FIG. 18.—ANNUAL GOODS TON-MILEAGE FOR ALL RAILWAYS IN THE UNITED STATES.

Fig. 19.

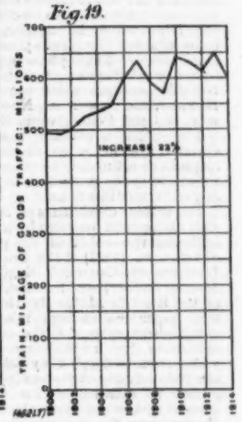


FIG. 19.—ANNUAL GOODS TRAIN-MILEAGE FOR ALL RAILWAYS IN THE UNITED STATES.

Fig. 20.

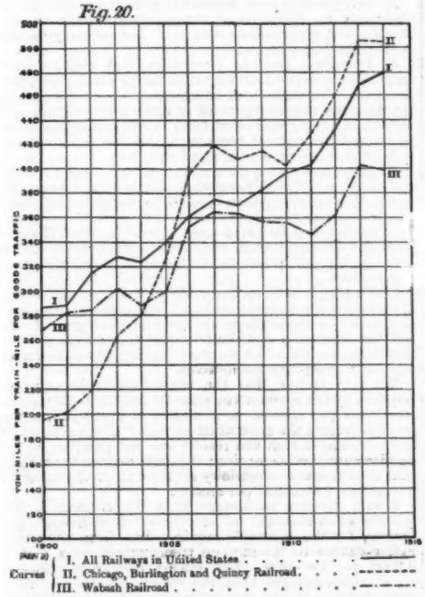


FIG. 20. RATIO OF TON-MILEAGE TO TRAIN-MILEAGE FOR GOODS TRAFFIC FOR ALL RAILWAYS IN THE UNITED STATES AND FOR TWO INDIVIDUAL CASES.

Percentage Increase in the Last Fourteen Years in the Ratio of Ton-Miles to Train-Miles for the Freight Traffic per Annum.

	Per Cent.
All United States railways...	68
Chicago, Burlington and Quincy Railroad	156
Wabash Railroad	48

The Annalist's article is entitled "A Triumph of Intensification." It is stated that although allowance must be made for certain factors which cannot be easily calculated, the percentage increase in the ratio of ton-miles to train-miles is a measure of the extent to which the railroads have been able to intensify their freight traffic. The article goes on to state that:—"A number of factors have contributed to this result. Increasing wages and other operating costs have compelled the railroads, as a matter of self-preservation, to effect economies in operation which were unknown at the beginning of the period. They have learned first—and it is perhaps the most important knowledge of all—that the most profitable train to run is the one which does not move until it has been filled to engine capacity. Therefore they strive continually not only to accomplish that, but to increase the capacity of the locomotive as well, so that the load in turn may be further increased. In the twelve years ended with June 30, 1914, the average tractive power of American locomotives increased by approximately 50 per cent. This has also resulted in increasing the size of other equipment. The average capacity of a freight-car is now about 40 per cent. greater than it was fifteen years ago."

Fig. 21.

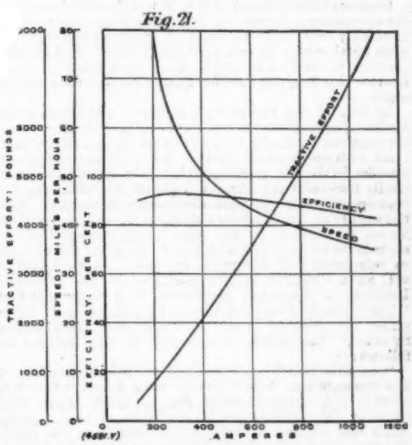


FIG. 21.—CHARACTERISTIC CURVES OF MOTOR FOR "1913" TYPE OF NEW YORK CENTRAL PASSENGER LOCOMOTIVE.

The points brought about in the present lecture render it almost superfluous to call attention to the inevitability of the rapid introduction of the electric locomotive in the further pursuance of the policy discussed by *The Annalist*. While the steam locomotive, as stated in *The Annalist's* article has increased in twelve years by 50 per cent., in the feature of the average tractive effort of which it is capable, there has been no notable increase in the speed of freight locomotives. The electric freight locomotive provides any tractive effort permitted by the draft rigging, and also provides any increase in speed permitted by curves, and strength of freight-cars and permanent-way. It has been shown in the paper that the heaviest freight-trains may, with electric locomotives, be propelled over heavy grades at twice the speed possible with steam locomotives.

PASSENGER LOCOMOTIVES ON THE NEW YORK CENTRAL RAILWAY.

The 600-volt electrification of the New York Central Railway, which at present comprises 52 route-miles (or 251 miles of single track), and extends on one division 34 miles from the Grand Central Station, in New York City, is now an old story, and no general description is necessary. It is briefly touched upon in this paper with the object of describing the "1913" type of electric locomotive, of which sixteen are now in service, in addition to the forty-seven original locomotives, which date from 1906.

This "1913" locomotive, which weighs 115 British tons, is designed for high-speed passenger service. Its continuous rating is 2000 horse-power, and corresponds to a tractive affort of 13,840 lb. at 54.5 miles per hour. Its 1-hour rating is 2600 horse-power, and corresponds to a tractive effort of 20,400 lb. at 48 miles per hour. The locomotive operates from a 600-volt conductor-rail. The two-axle guiding-trucks at each end are each fitted with two motors. These, with the four motors carried by the articulated middle truck, make a total of eight motors for the locomotive. The entire weight is on drivers, the weight per axle being 14.4 tons. Each motor has a continuous rating of 250 horse-power. For this rating a volume of 3000 cub. ft. of air per minute is blown through it. The motors are bipolar, and their armatures are mounted directly on the axles, gearing losses thus being eliminated. The locomotive is suitable for all speeds up to 75 miles per hour.

These locomotives haul, at 60 miles per hour, trains with a total weight of 1100 British tons. The tractive effort of 20,400 lb., corresponding to the 1-hour rating, only amounts to 8 per cent. of the weight on drivers, the locomotive's capacity being controlled by that of its electrical equipment, and not by any limiting coefficient of adhesion. The locomotive could haul the heaviest passenger trains over steeper grades than any on the New York Central Railway. A 1100-ton train on a 0.4 per cent. grade requires a tractive effort of about 20,400 lb., and the speed corresponding to this tractive effort is 48 miles per hour. For these conditions the "drivers-to-draw-bar" efficiency, on the assumption of equal resistance, in pounds per ton, for both locomotive and passenger coaches, is:—

$$\frac{1100 - 115}{1100} = 89.5 \text{ per cent.}$$

Owing to the absence of gearing, the efficiency of the electrical equipment is exceptionally high. The characteristic curves for the motor employed are given in Fig. 21, and the efficiency of the motors, for a speed of 48 miles per hour, is seen to be 91 per cent. Allowing an additional 2.5 per cent. to cover the energy consumed by the blower and other auxiliaries, we have:—

	Per Cent.
Efficiency of electrical equipment	88.5
"Drivers-to-draw-bar" efficiency	89.5
Efficiency from collecting-shoe to draw-bar	79.2

The total locomotive weight of 112 British tons is made up of 167,000 lb. of mechanical equipment and 83,000 lb. of electrical equipment.*

RELATIVE EXTENT, IN 1915, OF SINGLE-PHASE AND HIGH-PRESSURE DIRECT-CURRENT ELECTRIFICATION.

In the table on the next page are given data of the growth in the United States of single-phase and high-pressure direct-current electric railways during the last nine years.

It should not be concluded from the data in the above table that there is no longer any activity in America in

* James Forrest Lecture, delivered before the Institution of Civil Engineers, on Tuesday, December 14, 1915. In the enforced absence of Mr. Hobart in America, this lecture was delivered on his behalf by Mr. John A. F. Aspinall, M. Inst. C.E.

* This is the weight of the locomotive as delivered. The subsequent addition by the railway company of heating equipment and certain other accessories has increased the weight to about 119 British tons.

Total Mileage of Single Track Operating and Under Construction.

Year.	Single-Phase.	High-Pressure Direct Current.		
		1200 and 1500 Volts.	2400 and 3000 Volts.	Total for High-Pressure Direct Current.
	miles	miles	miles	miles
1906	60	—	—	—
1907	1040	—	—	—
1908	1130	—	—	—
1909	960*	—	—	—
1910	990*	600	..	600
1911	1040*	1140	..	1100
1912	1040*	1600	100	1700
1913	940*	1200	200	2400
1914	1340	2750	450	3200
1915	1490	2810	910	3720

* The falling off in increase in single-phase mileage during 1909 to 1913 was partly due to changing over eight roads (aggregating over 300 miles of single track) from single phase to direct current.

applying the single-phase system to railways. For tramways and light railways single-phase apparatus is generally admitted to be inferior, and no new undertakings have adopted the single-phase system for several years. But extensive single-phase applications have been made in the electrification of sections of main-line railways. Notable amongst these are the Norfolk and Western Railway, the New York, New Haven and Hartford Railway, and the Pennsylvania Railway.

The author is satisfied that the high-pressure direct-current system is so distinctly superior in essential respects as ultimately to ensure its general use on main-line railways in preference to the single-phase system or any of its modifications.

The serious disabilities of the single-phase system were well understood long ago by a small number of engineers, including the author of the present paper. At page 31 of vol. xxvi. (1907) of the Transactions of the American Institute of Electrical Engineers appears a paper by Messrs. Stillwell and Putman, entitled "The Substitution of the Electric Motor for the Steam Locomotive." In that paper the authors take the standpoint that the single-phase system is the only system worthy of consideration for railway electrification. "Where, ten years from to-day," they ask, "will be the 1200-volt or the 1500-volt direct-current systems which have been suggested as substitutes for high-potential alternating-current systems in heavy electric traction?" In *The Times* Engineering Supplement for April 10, 1907, I expressed the opinion that the authors of that paper had "allowed a desire, shared by all engineers, to secure the best system for long-distance work to supplant sufficient study of adverse details in the single-phase system." I went on to state my opinion "that within ten years direct-current systems, as applied to railway electrification, will employ line pressures more of the nature of 2000 or 3000 volts, and these systems will—in all probability—have come into extended use. The single-phase delusion will meanwhile have been exposed." Only eight of the ten years have yet elapsed, and we can record very satisfactory progress toward the fulfilment of this expectation. It should, however, be clearly understood that some of the original advocates of the single-phase system continue to suggest that it is the most appropriate. Mr. B. G. Lamme, in *The Electric Journal* for October, 1913, closes an article as follows:—

"It would appear, therefore, that the single-phase system, taken in its broad sense, presents possibilities not found with any other general system yet proposed. At present the system allows the use of two radically different types of equipment—namely, the straight single-phase and the split-phase—while certain other types present very great possibilities. Thus the system appears to be broadening out in its application, instead of narrowing, which is a most promising feature. With this one general system, terminal and yard work, main-line service, tunnel operation, mountain grade work, branch line and feeders, &c., can all be handled."

In the August, 1915, issue of the Proceedings of the American Institute of Electrical Engineers is a paper by Mr. W. S. Murray, Consulting Electrical Engineer to the New York, New Haven and Hartford Railway, entitled "Conditions Affecting the Success of Main-Line Electrification." At page 1885 of this paper Mr. Murray says:—

"At this juncture it is of interest to point to the fact that under the single-phase, high-potential contact-wire three types of electric motive power—the single-phase, the three-phase, and the direct-current (through the medium of a rectifier)—can operate; thus each class of equipment is permitted a supply of power unchanging in form.

"The principle of cardinal importance to the writer's mind, and one of the conditions affecting the success of main-line electrification, may therefore be said to be the establishment of a standard system of power distribution, from the contact-wires of which shall be delivered power in standard and unchanging form; and while all electric locomotives or multiple-unit equipment will primarily receive this power in identical form, it may thereafter be modified or transformed to conform to any type of alternating-current or direct-current equipment, which is, in turn, prescribed by the local conditions. Such a standardisation would provide a single high-voltage contact-wire running throughout an entire electrification zone upon which are impressed 11,000 volts of 25-cycle single-phase electricity."

Again, at page 1882 of Mr. Murray's paper, we find:—

"The recent decision as to choice of system on the part of the Pennsylvania Railroad in favour of single-phase for the proposed electrification on the main line between Philadelphia and Paoli, this action being a forecast of the system to be employed in the event of the future financial situation permitting electrification between New York and Washington, was one of no small consequence and pleasure to those who had been toiling to establish a correct application of electrification to trunk-line territory.

"To those who every day had been in close association with the practical workings of this system initially installed on the New Haven, failures were too closely associated with cause and effect to suggest even disappointment, to say nothing of discouragement; but let me refer to an admirable and fine distinction as evidenced in the decision of Gibbs and Hill, which discounted apparent for real results, and settled that the body of their electrification should be upon a single-phase basis, notwithstanding that the largest terminal upon the same railroad was operated upon a direct-current basis."

It is not proposed in this paper to deal quantitatively with the relative merits of single-phase and direct-current locomotives further than to state the author's conclusion that, owing to the lower "drivers-to-draw-bar" efficiency and the lower efficiency of the electrical equipment of single-phase locomotives, a given output from the draw-bar will (taking into consideration all the varieties of traffic on a railway) require so much greater consumption of electricity by the locomotives as to fully offset any economies in sub-stations and distribution system. This conclusion concerning the relative consumption of the two types simply refers to one of the items entering into a comprehensive comparison. Amongst other matters requiring consideration are the relative initial costs of locomotives of equal capabilities of the two types—the relative outlays for repairs, and the relative reliability.

An interesting sidelight is thrown on the superiority of the direct-current motor by the following statement by Mr. Murray at a meeting of the New York Railroad Club on March 15, 1915, in commenting on the "rectifier" locomotive:—

"In the alternating current supplied to our passenger engines now operating between New York and New Haven by the use of the rectifier there is permitted an increase of about 50 per cent. in traction, with all of the speed characteristics that these engines now possess retained. This characteristic will doubtless permit us to avoid the necessity of the purchase of a large number of passenger engines in the future as our passenger traffic increases, as our alternating-current direct-current engines can be converted into rectifier engines in proportion to the increased traffic requirements, the cost of this change-over being only a small percentage of the cost of new engines."

Here we have a record of Mr. Murray's experience that the commutator motors on his single-phase locomotives have only two-thirds as great an output when supplied with single-phase as when supplied with direct-current electricity, and that single-phase equipment is much heavier for a given output than direct-current equipment.

In view of the increasingly-frequent allusions in the technical press to the use of rectifiers on "single-phase" locomotives, it should be pointed out that a rectifier supplied with single-phase current differs from a polyphase rectifier in that it does not inherently supply the practically non-pulsating current required for obtaining the best operating results from direct-current motors. Also the supply of single-phase electricity to such locomotives leaves the system on the same unsatisfactory basis as regards its constituting a source of inductive disturbance to telephone and telegraph systems. At page 136 of vol. xxxi. (1912) of the Transactions of the American Institute of Electrical Engineers, in a paper entitled "The Relative Costs and Operating Efficiencies of Polyphase and Single-Phase Generating and Transmitting Systems," the author commented on this subject as follows:—

"At this point I am tempted to include mention of the consequences which would result from the development of large static-rectifier sets. It would appear that those of the mercury-arc type will be at least equally small and efficient at high periodicities as at low periodicities. If further developments bear out this indication, then the use of mercury-arc rectifiers in sub-stations as an alternative to synchronous converters will permit (when the periodicity is not fixed by other conditions) of employing periodicities of 60 cycles per second with the associated advantages as regards lower price and higher efficiency of the step-down transformers. On this plan, the transmission would continue to be polyphase. But if (as some single-phase advocates propose) static rectifiers are placed on the train and employed to supply direct-current motors, the difficulties relating to the impedance of steel rails would continue to necessitate the use of low periodicities such as 25 or even 15 cycles per second, or else it will be necessary to supply liberal copper feeders tapped off to the rails at frequent intervals.

"The indications are that the commercial development of static rectifiers of large capacity will increase the range of appropriate application of the three-phase system with sub-stations and employing direct-current motors on the trains, or, conversely, and contrary to the usual prediction, will greatly narrow the range where the single-phase system is economically more appropriate. But the chief cause for satisfaction, and one which will be shared by all electrical engineers, is that any such development of static rectifiers will increase the range or work where electrical methods of operating trains will be economically more appropriate than steam-locomotive methods. Judging from the properties of mercury arc rectifiers, large polyphase static rectifiers will be not only more efficient than, but also considerably cheaper than the equivalent synchronous converters, and this, together with the probable practicability of employing a periodicity of 60 cycles per second, will materially decrease the cost of the electricity required for given train operations."

When consideration is given to the characteristics of single-phase and direct-current locomotives, we find ourselves faced with the purchase at the point of delivery to the sub-stations either of a given quantity of single phase lagging power-factor electricity or an appreciably less quantity of three-phase unity power-factor or even leading power-factor electricity. It will rarely be practicable to supply the former kind of electricity to the sub-stations at a price per kilowatt-hour less than 30 per cent. in excess of that at which the latter kind of electricity can be profitably supplied to the sub-stations.

In America by far the most usual periodicity is 60 cycles per second. Most of the great transmission systems employ 60 cycles. If the single-phase system were to be employed by a railway purchasing 60-cycle electricity, it would be necessary to equip the sub-stations with motor-generator sets. Such motor-generator sets would consume 60-cycle three-phase electricity, and deliver single-phase 25-cycle electricity. On this plan, the sub-stations with the single-phase system would be on the same basis, as regards the greater first cost and the lower efficiency of rotating machinery, as the direct-current system, leaving the single-phase system at a disadvantage as regards both total first cost and annual over-all efficiency from generating-station to draw-bar of locomotive. The same considerations apply in Great Britain and other countries in which by far the most usual periodicity is 50 cycles per second. It would either be necessary to employ separate generating stations to provide the 25-cycle single-phase electricity, and forego the advantages of high load-factor and diversity factor, or else interpose motor-generator sub-stations of the same order of cost and efficiency as the motor-generator sub-stations required for the high-pressure direct-current system.

Cost of Electricity at the Locomotive.

At this point it is of interest to investigate the cost of electricity as delivered at the locomotive with direct-current and single-phase systems. Let us compare the three following systems:—

A. Polyphase 60-cycle generation and high-pressure transmission to sub-stations where the pressure is stepped down, the electricity then being delivered into polyphase synchronous motors operated at unity power-factor, and afterwards being delivered from direct-connected high-pressure direct-current generators, and thence distributed to high-pressure direct-current locomotives.

B. Polyphase 60-cycle generation and high-pressure transmission to sub-stations where the pressure is stepped down, the electricity then being delivered into polyphase synchronous motors operated at unity power-factor, and afterwards being delivered from direct-connected 25-cycle single-phase generators, and thence distributed at an average lagging power-factor of 0.75 to single-phase locomotives.

C. Single-phase 25-cycle generation (in large stations for supplying many locomotives) and high-pressure transmission to sub-stations where the pressure is stepped down, and the electricity distributed direct from the step-down transformers, and at an average lagging power-factor of 0.75, to single-phase locomotives.

We may assume that the electrification in question requires at the locomotives some 70 million to 90 million kw.-hours per annum, or a matter of about 100 million kw.-hours from the generating-station. The comparisons are so arranged that the results are independent of the precise annual consumption; it is only desired to indicate that the amount of electricity required is of the order of 100 million kw.-hours per annum.

System A.—Let us assume that, for System A, 160 million kilowatt-hours of electricity is delivered per annum, for the railway's requirements, from the generating-station to the step-up transformers, at a cost of 0.290d. per kw.-hour. Let this low cost be in part due to the circumstance that the supply-station has other large consumers, and that were it not for the diversity factor of the railway load with relation to the loads taken by these other consumers, the cost of the 100 million kilowatt-hours required by the railway would have been 6 per cent. greater—*i. e.*, 0.307d. per kw.-hour. Furthermore, let the cost of 0.290d. per kw.-hour be based on a load-factor at the generating-station of 0.50 for the 100 million kilowatt-hours of railway load. While at the present state of the art these various assumptions are all reasonable under favourable conditions, and with thoroughly modern design, it would not be right to infer without investigation that in any particular case it would be practicable to supply electricity at prices based on so low a cost. The assumptions are employed because they are attainable under favourable circumstances, and are consistent with one another. The employment of a higher basic cost, while it would be without much influence on the final conclusions, would have relegated the values to times and conditions from which we are emerging, instead of adjusting them into consonance with the conditions upon which the art is now entering. The investment and operating costs (the latter being chiefly represented by the losses) in the 60-cycle polyphase step-up transformers will increase the cost of the electricity (expressed in terms of the output from the transformers) by 0.013d. per kw.-hour, making it (0.290 + 0.013 =) 0.303d. This is based upon the market value of such transformers, on appropriate values for interest, depreciation, taxes, and insurance, and on an annual over-all efficiency (of the transformers) of 97.5 per cent. Let the average distance of transmission be 100 miles, and let the conductors be proportioned for an annual over-all efficiency of trans-

mission of 95.0 per cent. The investment and operating costs associated with the transmission line (exclusive of step-up and step-down transformers) will increase by 0.063d. per kw.-hour the cost of the electricity delivered from its distant end, making the cost at that point 0.386d. per kw.-hour. The polyphase 60-cycle step-down transformers will have an annual over-all efficiency of about 97.0 per cent. Their investment and operating costs will increase the cost of the electricity by 0.017d. to 0.403d. per kw.-hour of electricity delivered from them. The annual over-all efficiency of the motor-generator sets in sub-stations may conservatively be taken at 0.87 per cent. The investment and operating costs of the sub-stations (exclusive of the step-down transformers, which have already been considered) will increase the cost of the electricity delivered from them by 0.175d. to 0.578d. per kw.-hour. Taking the distribution system—*i.e.*, the system intermediate between the sub-stations and the locomotives—as having an annual over-all efficiency of 92 per cent., we may assess the increase in the cost of the electricity due to the investment and operating costs of the distribution system at 0.160d. per kw.-hour, bringing up the cost of the electricity at the locomotives to 0.738d. The annual over-all efficiency of the system from the outgoing cables at the generating-station to the pantographs on the locomotives is—

$$0.975 \times 0.950 \times 0.970 \times 0.870 \times 0.920 \times 100 = 71.8 \text{ per cent.}$$

System B.—In this case we have, up to the motor-generator sets in the sub-stations, the same results as for System A. But the generators of the motor-generator sets are now single-phase machines instead of direct-current machines. Notwithstanding the absence of commutators, the single-phase generators do not represent any lower cost or better efficiency, even although, owing to the use of 11,000 volts as against 3000 volts, there may be employed less sub-stations, each sub-station having sets of larger capacity and having a better load-factor. It does not seem to be generally recognised that a single-phase generator of a given output in kilowatts, but supplying a lagging load of 0.75 power-factor, costs fully twice as much, and has considerably lower efficiency than a three-phase unity power-factor generator for the same rated output, equal temperature rises being assumed in the two cases. Taking into account these disabilities of single-phase generators, even the lesser number of sub-stations and the better load-factor does not decrease the addition to the cost debited to the sub-stations in System A, but we will credit the motor-generators with the same annual over-all efficiency of 87 per cent. Thus at the point of delivery from the sub-stations, the cost of the electricity is the same as in System A—namely, 0.578d. per kw.-hour. For the distribution system, however, the investment cost will be less than for System A, even for a higher annual over-all efficiency, which we will take at 0.96 per cent. (as against 0.92 per cent. for System A). The investment and operating costs associated with the distribution system will increase the cost of the electricity by 0.100d. to 0.678d. per kw.-hour at the points of delivery to the locomotives of the 0.75-power-factor lagging electricity. The annual over-all efficiency of System B from the outgoing cables from the generating-station to the pantographs on the locomotive is—

$$0.975 \times 0.950 \times 0.970 \times 0.870 \times 0.960 \times 100 = 75 \text{ per cent.}$$

System C.—The investment and operating costs of a generating-station for the exclusive supply of the 25-cycle railway load, per kilowatt-hour of output from the station, would be 0.315d. (as against 0.290d.) on account, firstly, of the sacrifice of the savings which may be effected with the high diversity factor of the railway load associated with the load of other consumers, and secondly, on account of the smaller annual output from the generating-station. But in addition to these considerations, it costs more to provide a given amount of electricity of 0.75-power-factor than of unity power-factor. From the considerations set forth on page 48 *ante*, it will be seen that on this account the cost will be increased from 0.315d. to 0.345d. per kw.-hour. There is still further additional cost due to the inherently higher cost and lower efficiency of single-phase as compared with polyphase generators. These differences are much greater than are generally conceded, and will increase the cost of the 25-cycle 0.75-power-factor single-phase electricity delivered from the generating-station in System C by a further 0.015d. per kw.-hour, bringing it up to 0.360d. at the point of delivery to the step-up transformers. The annual over-all efficiency of the 0.75-power-factor single-phase 25-cycle step-up transformers will be 96.5 per cent. Their investment and operating costs will increase the cost of the electricity by 0.023d., making it 0.383d. at the point of delivery to the transmission-line. Letting the pressure between the conductors of the single-phase transmission-line be 15 per cent. higher* than in the three-phase transmission-line employed in Systems A and B, and employing the same total cross-section of copper as in those cases, then for the transmission of the same total number of kilowatt-hours, but at 0.75 power-factor and single-phase the annual over-all efficiency of the transmission-line will be only 91 per cent. (as against 95 per cent. for the three-phase unity power-factor transmission-line of Systems A and B). The investment and operating costs (the latter being chiefly the cost of the energy dissipated in the transmission-line) of the transmission-line will add 0.105d. per kw.-hour, making the cost at the distant end 0.488d. per kw.-hour. The investment and operating costs of the sub-stations and their contents (the step-down transformers, whose annual over-all efficiency is 96 per cent., and the switch-gear) increase the cost by 0.040d., bringing it up to 0.528d. per kw.-hour as delivered from the sub-stations. The investment and operating costs of the distribution system are 0.097d., a trifle less than for System B (since the cost of the electricity dissipated in the distribution system is slightly lower), making the cost of the 0.75 power-factor single-phase electricity delivered to the locomotives 0.625d. per kw.-hour. The annual over-all efficiency of System C from the generating station to the pantographs on the locomotives is—

$$0.965 \times 0.910 \times 0.960 \times 0.960 \times 100 = 80.9 \text{ per cent.}$$

In the following table are brought together the costs of the electricity at the locomotives for the three systems. Regeneration is not taken into consideration in the table; but it should be pointed out that, while considerable gains are available with regeneration in System A, the split-phase type of single-phase equipment is the only one permitting of the commercial utilisation of regeneration, and that even then the range of speeds permitting of its use is relatively limited. It should be obvious from the nature of the method of comparison that the efficiencies of the different systems do not constitute criteria of their relative economy, since costs are assessed to each loss when it first comes up for consideration.

Cost of the Electricity in Pence per Kilowatt-Hour.

—	System A.	System B.	System C.
As delivered from generating-station ..	0.290	0.290	0.360
,, ,, step-up transformers	0.303	0.303	0.383
,, ,, transmission-line ..	0.386	0.386	0.488
,, ,, step-down transformers	0.403	0.403	0.528
,, ,, sub-stations	0.578	0.578	0.528
,, to locomotives	0.738	0.678	0.625

Although various kinds of service, such as hauling local and express passenger-trains, freight-train service of various classes, and switching* service, affect the extent to which single-phase locomotives are handicapped as regards current consumption, they will, even under the most favourable conditions, not be likely to consume less than 15 per cent. more electricity than direct-current locomotives for the same output at the draw-bar averaged over the entire traffic of a railway. Taking this percentage, relative figures for the outlay for electricity are derived in the following table :—

—	System A.	System B.	System C.
1. Cost of electricity as delivered at the locomotives .. per kw.-hour	0.738d.	0.678d.	0.625d.
2. Relative consumption of electricity at locomotive pantographs ..	1.00	1.15	1.15
Product of 1 and 2	0.738	0.780	0.719
Ditto in terms of total cost of electricity for System A taken as 100 ..	100	106	97.5

The 6 per cent. and 2.5 per cent. differences are too small to be considered in this rough comparative study. Consequently we may, on the basis of our assumptions, which have certainly not favoured the direct-current system, take the outlay for electricity as about the same for the three systems, leaving the single-phase systems handicapped by the greater inherent cost of single-phase locomotives. If, up to the locomotive, any material savings could have been demonstrated for the single-phase system, then the correct choice would be influenced by the density of traffic; the greater outlay per single-phase locomotive with a sparse traffic being more than offset by the savings up to the locomotive, while with a dense traffic the greater outlay per single-phase locomotive would more than offset any savings up to the locomotive. Since, however, up to the locomotive the costs are a stand-off, it would appear that even with a sparse traffic the direct-current system is the most economical, and that the percentage by which it is more economical increases with the percentage which the locomotive investment bears to the total investment.

The conclusions of this paper are to the effect that: First, we are on the eve of the extensive employment of electric locomotives on railroads at present operated with steam locomotives; second, that the direct-current system is the most appropriate; and, third, that direct-current locomotives for use from high-pressure contact conductors are now a thoroughly demonstrated success.

The author wishes to acknowledge his indebtedness to Messrs. W. B. Potter, G. H. Hill, A. H. Armstrong, J. B. Cox, C. J. Hixson, E. S. Johnson, John Liston, and W. D. Bearce for much cordially rendered co-operation in the preparation of this lecture.

The President remarked that the James Forrest lecture was not submitted to the criticism of the members; but he thought their opinion of the lecture just delivered would only be in its favour. The deductions were drawn from facts, and were of a most interesting character. He moved a cordial vote of thanks to the lecturer, Mr. Hobart, and to Mr. Aspinall.

The resolution having been carried by acclamation, Mr. Aspinall thanked the members on behalf of Mr. Hobart and himself.

* This 15 per cent. higher pressure between conductors corresponds to the same pressure between conductors and ground for both systems.

* The greater the proportion of switching service, the greater will be the ratio of single-phase consumption to direct-current consumption for a given total output at the draw-bars of all the locomotives in all services, partly owing to the inferiority of the single-phase system with respect to the "drivers-to-draw-bar" efficiency.

JAPANESE IMPORTS.—The value of the imports into Japan in 1914 was 60,814,700*l.*, as compared with 74,462,813*l.* in 1913, and 63,188,795*l.* in 1912. In these totals the imports from Great Britain and British possessions figured in 1914 for 27,893,900*l.*, as compared with 32,594,400*l.* in 1913, and 27,557,000*l.* in 1912. The imports from the United States represented a value of 9,878,700*l.*; from China, 5,952,000*l.*; from Kwangtung (province), 3,192,900*l.*; from Germany, 4,585,800*l.*; from the Dutch Indies, 2,248,400*l.*; and from French Indo-China, 1,536,600*l.*

CONTEMPLATED ELECTRIFICATION OF NORWEGIAN RAILWAYS.—Although Norway has been left behind as compared with Sweden in the matter of State railway electrification, the question has by no means been shelved. On the contrary, preparatory work on a considerable scale has been, and is at the present moment, proceeding; and as regards the Christiania-Drammen railway, the electrification has been decided upon, and will no doubt be finally arranged in due course. The plans for the electrification of this line are ready, and will in the course of January be submitted to a committee of experts, comprising two Swiss, one German, one Swedish, and one Norwegian engineer—all authorities in the domain of railway electrification. The system to be adopted for the whole country's railway electrification has to be decided upon now, hence the necessity of such a representative committee. In the meantime a general plan has been drawn up for the electrification of all the Norwegian railways. The necessary amount of power has been calculated, and the localities fixed upon where this power is wanted. Also the different transformer stations have been located, and the areas which are to be worked from the different power-stations have been specified. The plan involves the purchase of some more waterfalls, and it is proposed to build the hydro-electric power-stations by degrees, and in such a manner that they can supplement each other. As regards the power for the first line to be electrified, the Christiania-Drammen railway, it has not yet been decided from what source it will be obtained. It was originally intended to draw the power from the future large power-station to be built at the Nore Falls, owned by the State, but as the exploitation of these falls has been delayed, it has even been under contemplation to fall back upon a steam central station. At the present time, however, negotiations are proceeding between the Norwegian State and the Christiania Municipality on the joint exploitation of the Mörkfos and Solbergfos Falls, in which case some 15,000 horse-power will be available, and if this arrangement comes about, the energy will also be used on the Drammen line. The exploitation of these two falls can then be followed by that of the Hakavik and the Nore Falls, all of which can work together, and, by degrees, further exploitations can be taken in hand.

THE SOUTH VARANGER IRON ORE COMPANY.—At the last general meeting of the South Varanger Company it was stated that a new issue of 222,000*l.* had been fully subscribed, and the chairman gave a short survey of the company's development during the past ten years, which is not without its interest, inasmuch as it shows how serious technical difficulties can be overcome. The company had to face great commercial and technical problems, by working out new methods and introducing upon the world's market a practically new article. But the difficulties have been overcome, and the company's products have now gained a firm position on the international market, and undoubtedly hold the first place in regard to iron ores low in phosphorus. The year 1915 would undoubtedly have resulted in the shareholders for the first time obtaining a dividend had it not been for the war; but otherwise the year has only served to demonstrate the vitality of the company. In spite of the daily increasing difficulties, in spite of the serious limitations to export, the company has been in full operation during the whole time the war has lasted. As soon as the war trouble began to loom steps were taken to meet the new order of things, with a view to keeping the large staff of workmen employed, and for the sake of the neighbourhood, for which the company has become a factor of great importance. The first five years of the ten which have now passed were exclusively devoted to organisation and erection of plant, &c.; the second to working with continued extension of capacity. The board is convinced that the next ten years will fulfil all promises. The production will be increased to 900,000 tons of finished materials, representing an actual working of some 2,000,000 tons of ore. The capacity of the deposits is estimated at from 500,000,000 tons to perhaps 1,000,000,000 tons. Diamond borings more than 100 metres deep, borings which in many instances went considerably below the level of the sea, have, as far as the larger deposits are concerned, shown no falling off in the iron ore. The number of hands employed, also during the war, amounts to about 1400, and owing to many and various difficulties as regards tonnage, stocks of concentrate have accumulated and are now stated to amount to some 500,000 tons. During the war the men have received part of their wages in vouchers, which both the local bank and the tradesmen accept as ready money; now full cash payment again obtains, and the vouchers still in circulation will be redeemed by the company.

CATALOGUES.

Electric Lamps and Fittings.—Price-lists dealing, respectively, with "Osram" drawn-wire incandescent lamps, and fittings for use with half-watt lamps, have been issued by the General Electric Company, Limited, of 67, Queen Victoria-street, E.C.

Metallic-Filament Lamps.—Messrs. Dick, Kerr and Co., Limited, of Abchurch Yard, Cannon-street, E.C., have issued a price-list of metallic-filament lamps manufactured by them at their Preston works. As an advertisement for these lamps they are also distributing cardboard lamp-shades and reflectors suitable for the present lighting restrictions.

Electric-Light Fittings.—From Engineering and Arc-Lamps, Limited, of Sphere Works, St. Albans, we have received an illustrated price-list of fittings for use with half-watt lamps. These fittings are suitable for works, office, street, and shop lighting, and cover practically all requirements for such installations. Some of them, we notice, are fitted with glazed lanterns instead of globes, the former giving an excellent light distribution, and being much less costly to replace than the latter.

Milling-Cutters, Reamers, &c.—Sir W. G. Armstrong, Whitworth and Co., Limited, of Openshaw, Manchester, have issued a useful catalogue of involute gear-cutters milling-cutters, metal-slitting saws, end-mills, slot-cutters, hand and machine reamers, and other small tools manufactured in their well-known "A. W." brand of high-speed steel. Prices are stated for all these tools, and some examples of broaches are illustrated in the catalogue.

Cooking Apparatus.—A circular giving some particulars of apparatus for cooking or warming up food on a large scale, and suitable for employment in munitions works and other factories, has reached us from Messrs. Benham and Sons, Limited, of 66, Wigmore-street, W. The apparatus includes hot-closets, ovens, hot-plates, steam-jacketed pans, &c., heated by gas, steam, or coal-fires. Examples of the apparatus are illustrated, as also are some kitchens completely equipped by the firm.

Pyrometers.—A copy of their latest catalogue of pyrometers has reached us from the Cambridge Scientific Instrument Company, Limited, of Cambridge. This catalogue is devoted to pyrometers of the thermo-couple type, suitable for measuring temperatures up to 1400 deg. Cent. under industrial conditions. Particulars are given of indicators of the stationary and portable types, thread recorders, and thermo-couples, as well as of accessory apparatus, such as connecting leads, switches, &c. Some illustrations showing different methods of mounting thermo-couples are also included.

Furnaces for Munitions Work.—We have received from the Alldays and Onions Pneumatic Engineering Company, Limited, of Great Western Works, Birmingham, an illustrated catalogue section giving prices and particulars of furnaces for munitions manufacture. The catalogue includes shell-nosing furnaces, forging furnaces, hardening and annealing furnaces, tyre-heating furnaces, lead and salt-bath furnaces, tilting crucible furnaces, scrap-heating furnaces, &c., using gas, oil, or coal as fuel. Accessories, such as fans and blowers, pyrometers, and gas and oil-burners are also included.

Cranes, Hoists, Winches, &c.—Mr. B. J. Allison, of Tower Chambers, 118, London Wall, E.C., has sent us a number of weekly bulletins published by Messrs. Figee, Limited, of Haarlem, Holland, for which firm he is the sole British agent. The bulletins, which are contained in a strong binding-case, illustrate examples of Messrs. Figee's products, including practically all types of cranes operated by steam, electric, or hydraulic power, as well as transporters, overhead-runways, pile-driving plant, capstans, grab-buckets, winches, and hauling-up gear for slipways. The illustrations, which are very well printed, are all reproduced from photographs of actual installations.

Portable and Semi-Portable Steam-Engines.—A sectional catalogue of portable and semi-portable steam-engines has been issued by Messrs. Marshall, Sons and Co., Limited, of Gainsborough. Both types of engine are made with single cylinders, in sizes ranging from 2 to 12 nominal horse-power, while double-cylinder and compound engines are made from 8 to 40 nominal horse-power. These engines are fitted with the firm's patent fire-box with cambered top sheet, which was illustrated and described on page 779 of our ninetieth volume. It is claimed that the shape of the top of the fire-box considerably retards the formation of scale, and at the same time greatly facilitates cleaning owing to the absence of roof-bars and stays. The weight of the boiler is also reduced, and there is a slight increase of heating surface at the part where it is of most value.

Wood-Boring Machine.—Messrs. Matthew Wylie and Co., of 81 and 83, Portman-street, Kinning Park, Glasgow, have sent us a circular giving some particulars of their multiple-spindle wood-boring machines. These machines are made with a horizontal cross-head, either 30 in., 42 in., or 60 in. long, on which any number of boring-spindles can be fitted to bore holes spaced on centres not less than 2½ in. apart, and either in a straight or zig-zag line. The spindles are each driven independently by means of phosphor-bronze bevel gears, and can easily be adjusted to vary the spacing as required. The work is placed on a balanced table which can be set at any angle, and raised by means of a foot-lever to feed the drills into the work. If necessary, specially-designed heads can be supplied for boring groups of holes on 1-in. centres.

Railway Motor-Cars.—The Drewry Car Company, Limited, of 13, South-place, Finsbury, E.C., have sent us a copy of their latest catalogue of railway motor-cars. These vehicles are propelled by internal-combustion engines, and are constructed in sizes ranging from a small two-seater inspection-car with a 4-horse-power engine to a double-bogie coach having a 150-horse-power engine, and carrying from fifty to sixty passengers. Many different cars are illustrated, and specifications of the standard models are also included. Of these the most popular is a 20-horse-power car carrying six persons at a speed of from 45 to 50 miles per hour on the level. A single charge of petrol (12 gallons) will take the car about 250 miles. These cars are very suitable for light passenger service on foreign and colonial railways, and a large number of them are so employed. They are entirely constructed at the company's works at Burton-on-Trent.

Gas-Fires.—We have received from the Richmond Gas-Stove and Meter Company, Limited, of 132, Queen Victoria-street, E.C., a catalogue illustrating and describing a new design of gas-fire they have recently brought out. In these fires, the heating elements, which consist of skeleton fire-clay tubes, are arranged in a semi-circle in plan, in order to distribute the heat uniformly over practically the whole of the room. The construction is such that but little heat escapes from the back of the fire, and polished nickel reflectors are provided at the sides, on the fender, and on the ledge of the canopy, in order to reduce the absorption of heat by the cast-iron parts and direct it out into the room. The reflectors also greatly improve the appearance of the fire, as their optical properties create an apparent increase in the area of the radiating surfaces. Other important claims made for these fires are that the burner is designed so as to ensure complete silence in burning, and ample ventilation is secured with an insignificant loss of heat.

Commercial Motor-Vehicles.—A very attractive catalogue of petrol motor-wagons has reached us from the Peerless Motor-Car Company, of Cleveland, Ohio, U.S.A. These vehicles are built in four sizes for loads of 3, 4, 5, and 6 tons, and each size is made with two lengths of chassis, to accommodate long and bulky or short and heavy loads. They can be supplied with bodies suitable for all kinds of heavy haulage work, including power dumping bodies for materials such as road-metal, coal, bricks, and other builders' supplies. They are also used to haul a two-wheeled trailer, the front end of which rests on the chassis, or to draw a separate four-wheeled trailer. A hundred typical installations of Peerless motor-wagons are illustrated in the catalogue by means of excellent half-tone engravings, which show very clearly the widely-varying classes of service to which they have been adapted. Messrs. Gaston, Williams and Wigmore, Limited, of Alexandra House, Kingsway, W.C., are the sole agents for Peerless motor-wagons in this country.

Drying Timber.—A pamphlet illustrating and describing their system of timber-drying has come to hand from the Sturtevant Engineering Company, Limited, of 147, Queen Victoria-street, E.C. Two types of plant, known respectively as the "progressive" and "compartment" systems, are employed, the former being generally used where there is a continuous supply of timber of about the same dimensions, and the latter when different sizes and qualities have to be dealt with. In the progressive system one or more tunnels are provided with a longitudinal line of rails, and the timber, piled on truck running on the rails, is gradually passed through the tunnels in the opposite direction to a current of heated air. It will be evident that with this arrangement the warm, dry air first comes into contact with the drier timber near the outlet end of the tunnel, while the green wood near the inlet end is acted upon by air which has been cooled and moistened in its passage among the timber in the first part of the tunnel. Whenever a truck-load of dry timber is taken out, a load of fresh wood is put in at the opposite end of the tunnel, so that the process goes on continuously. The air is supplied by a fan driven by a steam-engine or electric motor, and is heated by passing through a bank of steam-pipes. In the other system the timber is treated in separate compartments, one of which is devoted to each size and kind of timber when the quantity is sufficient. The temperature and humidity of the air supplied to the compartments can be regulated as required, hot, cold, and moist air being delivered to each compartment through separate ducts. Two fans, one of which delivers part of the air through a heater to the hot-air duct and part directly into the cold-air duct, are employed; the other fan draws moist air from the drying compartments and discharges it into the moist-air duct. By regulating dampers fitted in the ducts leading to each compartment, the drying conditions can be varied to give the best results with any kind of timber. The pamphlet illustrates several installations on both systems, and also deals with fans and heaters, timber trucks, hygrometers, and other accessory apparatus.

Locomotives.—Record No. 81 from the Baldwin Locomotive Works, of Philadelphia, Pa., U.S.A., gives some particulars of locomotives recently constructed by the firm for the Erie Railroad Company. One of these locomotives is a triple-articulated compound engine weighing over 426 short tons, and capable of exerting a tractive force of 80 short tons. It has three sets of eight-coupled driving-wheels, each 5 ft. 3 in. in diameter, with two-wheeled leading and trailing-trucks. The rigid wheel-base is only 16 ft. 6 in., though the total wheel-base amounts to 90 ft. There are two high-pressure cylinders, 36 in. in diameter, with a piston stroke of 32 in., driving the central group of wheels and exhausting into two pairs of low-pressure cylinders of the same dimensions, driving the front and rear groups of wheels respectively. The rear group of driving-wheels is placed under the tender, and the exhaust from the cylinders escapes through a pipe at the rear of the tank after passing through a feed-water heater. The exhaust from the front pair of low-pressure cylinders is discharged through the chimney as usual. The weight on the rear driving-wheels, of course, varies according to the quantity of fuel and water in the tender, and this part of the engine has accordingly been designed to develop a smaller tractive force than the front and central parts. This has been accomplished by using different steam-laps and different travels for the valves. The engine, however, is primarily intended for short runs in "pusher" service, so that there will usually be plenty of fuel and water in the tank when the maximum power is required. The firebox is of the Gaines type, and is fitted with a Street mechanical stoker. The grate area is 90 sq. ft., and there are 326 2¼-in. tubes, each 24 ft. long, and 53 flue-tubes 5½ in. in diameter, in which the superheater tubes are placed. The total heating surface is 6886 sq. ft., and the superheating surface 1584 sq. ft. Other interesting particulars and numerous illustrations of this remarkable engine are given in the Record, together with similar data relating to a 2-10-2 type and a 2-8-2 (Mikado) type engine for the same line. Another Record, No. 82, deals with locomotives for export, and gives illustrations and tabulated data of twenty-seven different types of engines built for railway lines and industrial concerns in many parts of the world. These engines, which are of widely varying capacities, are all constructed to gauge and templet, so that repairs can be carried out easily and rapidly. Quick delivery is often an important consideration in export orders, and, as an example of this, we may mention that one of the engines illustrated, a large Mallet compound, formed part of an order for thirty, of which the last was ready for shipment in less than nine weeks from the date of the receipt of the order.

The Panama Canal.—Following the complete suspension of traffic for slightly over three months—that is, since the passage of the Jamaica through the Canal on September 18—the channel at the bases of the Culebra slides was opened sufficiently, says the *Canal Record*, to allow the passage of six light-draught vessels on Monday, December 20. These were, in order of passage, the yacht Adrea; the cable-ship Cyrus W. Field; the passenger and cargo steamship Acajutla, belonging to the Salvador Railway Company's line; the yacht Sultana; the United States Navy gunboat Newport; and the dredge San Diego. These are all small vessels, their aggregate tonnage not being equal to one large vessel. The maximum draught of the vessels was 15 ft., drawn by both the Sultana and the Newport. The steamships Edison Light, Navajo, and Admiralen are still at the south end of the Canal, waiting at Pedro Miguel Lock, but efforts will be made to pass them through at the earliest opportunity.

Electrical Engineers' Pocket-Book.—We have received from the Technical Publishing Company, Limited, of 1, Gough-square, Fleet-street, E.C., a copy of the 1916 edition of the *Practical Engineer* Electrical Pocket-Book and Diary. This book is divided into thirty-six sections, the first of which is devoted to mathematical and other tables, units, &c., while the next few sections deal with conductivity and resistance, wiring systems, testing, instruments, and magnetism. Later sections relate to dynamos and alternators, transformers, rotary converters, and other machinery, as well as to lighting, traction, mining, and many other branches of electrical work. New sections relating to telephones, and first-aid in accidents, have been added, and another new feature included is a description of a simple method of calculating the flow of heat through furnace and oven walls. The standards for electrical machinery have been revised in accordance with the latest report of the Engineering Standards Committee, and many of the tables have been recalculated and recast. The price of the book, bound in cloth, is 1s. 3d. post free, or 1s. 9d. post free in "Peltine" binding; for foreign postage, the prices are 1s. 6d. and 2s., respectively, for the two styles of binding.

Dock Accidents.—Restrictions on lighting in the Metropolitan area have intensified the dangers of dock work in the South and East London districts. In the latter area two fatalities were occasioned by the change. In East London the number of reported accidents has continued to increase, but this was due partly to a remarkable growth in the volume of trade at the docks in the latter part of 1914. A decrease in work at Manchester docks occurred in the early days of the war, but a revival followed in consequence of a diversion of traffic from the East Coast. There were 675 accidents (including five fatalities) at Manchester docks in 1914; this was a reduction of 10 per cent. as compared with 1913. The chief complaint was against foreign vessels in failing to provide suitable gear for lifting hatchway beams. At Liverpool dock accidents fell to 1567 (including 39 fatalities) in 1914; this was a decrease of 18 per cent. as compared with 1913. The reduction in accidents in 1914 was primarily due to quietness in the shipping trade during the first nine months of the year. In November and December, 1914, there was a congestion at Liverpool docks, and this occasioned a large increase of accidents; 7 per cent. of the accidents occurred to persons who had been employed more than twelve hours. Some shipbuilders still turn out vessels with inadequate hold ladders; such defects were found in 1914 upon four large ships which had commenced trading from Liverpool; it was impossible to approach the ladders except by climbing over the winch or other structures unprovided with hand-hold or foot-hold.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

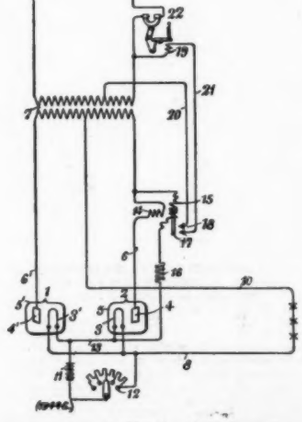
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the date of sealing is given.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

ELECTRICAL APPARATUS.

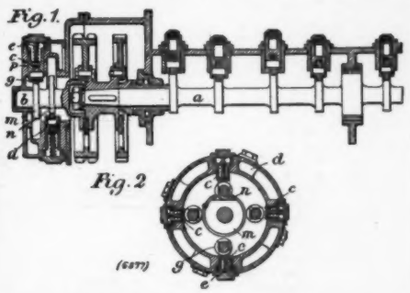
19,446/14. The British Thomson-Houston Company, Limited, London (*General Electric Company, Schenectady, U.S.A.*). **Rectifying Devices.** [1 *Fig.*] September 4, 1914.—This invention relates to the protection against overload of hot cathode vacuum tubes or other devices having a similar volt-ampere characteristic, and is particularly applicable to hot cathode rectifiers. When a hot cathode tube, so highly exhausted that its current is a pure electron discharge, is operated as a rectifier, current, of course, passes in one direction only, since such tube has what may be termed "unilateral conductivity," and that current furthermore is substantially constant in amount, regardless of the voltage of the source and the resistance of the load. In practice, such a tube is, of course, so designed with reference to the voltage and current required in the load circuit that in normal operation only a small part of the voltage of the source is consumed in the tube while the current is passing. But if, while the tube were thus operating, the load-circuit should be accidentally short-circuited, the current through the tube would remain practically constant, but the voltage across the tube would rise and the whole of the energy would then be consumed in the tube itself, and would quickly destroy the tube. Now ordinary protection devices would not protect the tube under these circumstances. The patentees utilise for the protection of the tube the fact that the dangerous condition involves the existence of a high voltage in phase with the current, and the invention consists in providing a protective device depending for its operation on the co-operation of current and of high voltage in phase therewith. The drawings illustrate the invention diagrammatically in a system for rectifying alternating current by means of incandescent cathode devices. The electron-discharge devices 1, 2 each comprise a filamentary cathode 3 adapted to be heated, and a co-operating anode 4, these electrodes being contained in a sealed envelope 5.



The space within the envelope is evacuated to such low pressure—for example, one-tenth of a micron of mercury or less—and the envelope and the electrodes are so completely freed from gas, that positive ionisation of residual gas by collision is substantially absent. The anodes 4, 4^1 are connected by conductors 6, 6^1 to the terminals of the secondary of the transformer 7. The cathodes 3, 3^1 are both connected to a conductor 8, which is connected to the load 9, the circuit being completed by a conductor 10 to a neutral point on the transformer secondary. The cathodes 3, 3^1 are both heated by a battery 11, connected in series with variable resistance 12 across the conductors 8 and 13. The current coil 14, connected in series with the anode conductor 6, and the voltage coil 15, connected to the cathode 3 and the anode 4 of the electron discharge device in series with a very high resistance 16, are respectively the current and voltage coils of a wattmeter-type relay. A flow of current coincidently through both coils causes a movement of the pivoted armature 17 in the well-known manner, bridging the contacts 18, and completing the circuit of a circuit-breaker controlling magnet 19 connected by conductors 20 and 21 across a section of the primary of a transformer at 7, or any other convenient source of current. When a short-circuit occurs across any part of the load 9, the voltage across the device 2 will be greater proportionately when the load-current is passing than normally when all the load is in circuit, as has been heretofore explained; that is, a short-circuit in the load will cause a proportionate increase of voltage in the coil 15 coincident with the passage of current through the coil 14, and will energise the magnet 19, thereby unlatching the circuit-breaker 22 and opening the primary circuit 23 of the transformer. Of course, in the same manner a resistance can be inserted in the supply circuit, instead of completely opening the circuit. A similar protective device may be provided for the discharge device 1, but this is not absolutely necessary, as the circuit will be opened in any event during the succeeding half-wave, if the short-circuit happens to occur while current is being passed by device 1. (*Sealed December 23, 1915.*)

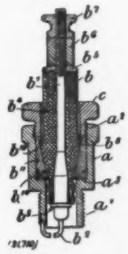
GAS-ENGINES, PRODUCERS, HOLDERS, &c.

6877/15. Societe Anonyme des Automobiles et Cycles Peugeot, Paris, France. Internal-Combustion Engines. [3 *Figs.*] May 8, 1914.—This invention relates to improvements in mechanism for regulating the rotatory movement of the cam-shafts of explosion motors. It is known that in an automobile motor a cam-shaft receives at the rising of the valve-tappet a thrust due to the tension of the spring and tending to reverse the direction of rotation of the shaft. These intermittent strains are produced as many times as there are tappets to be actuated, and the jerking movement of the cam-shaft is communicated to the distribution pinions, which result in wear of the bearings of the gears, producing chattering, during slow speeds. According to this invention, a regulating cam, keyed on the cam-shaft, operates as many regulating tappets as there are inlet distribution tappets for the motor, and a second regulating cam, also keyed on the shaft, operates as many regulating tappets as there are exhaust distribution



tappets for the motor. The apparatus represented is intended for a motor with four parallel cylinders, but it may be applied to a motor with any number of cylinders arranged in any manner. The cam-shaft a, assumed to be single in the present case, has at one end a member b, which may be joined to or form part of the cam-shaft, and arranged in any place in extension of the shaft. The member b carries an inlet-regulating cam m and an exhaust-regulating cam n. These cams rotate inside a member p, which may be either joined or cast in one with the casings of the motor. The member p is provided with eight housings intended to receive eight tappets, four of which, indicated by c, regulate the inlet tappets, and the other four, indicated by d, regulate the exhaust tappets. These eight tappets are pushed by springs e, having the same tension and the same flexibility as the springs of the valve-tappets. The regulating tappets c and d may or may not be provided with rollers; in the construction illustrated, rollers g are provided. The four inlet-regulating tappets are driven by the same regulating cam m, and the four exhaust-regulating tappets by another regulating cam n differing from the former. (*Accepted October 20, 1915.*)

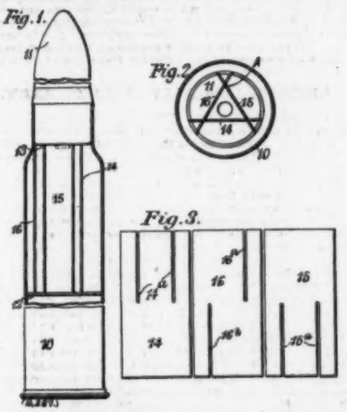
21,710/14. Electric Ignition Company (1913), Limited, and A. Cox, Birmingham. Sparking-Plugs. [3 *Figs.*] October 29, 1914.—This invention has reference to sparking-plugs of the type wherein gas-tight connection between a separable body-member and a combined electrode and insulator member is adapted to be made mechanically through the medium of a nut which, when screwed into the body-member, clamps an enlarged part of the electrode and insulation member between itself and a seating inside the body. According to this invention, the enlarged portion of the combined electrode and insulation member is externally tapered and is enclosed within an internally-tapered metal ferrule, the bottom or underside of which is also coned or tapered, and is adapted to be forced by the clamping-nut into gas-tight engagement with a correspondingly coned seating inside the body-member. The plug is constructed of three readily separable units or members—viz., a metallic plug-body a, a central rod-electrode and insulator unit b, and a locking-nut c. The body-member consists of a metal sleeve, which is formed, at one end, with the usual external screw-thread a^1 for connecting the plug to an engine cylinder, whilst its interior is screwed at a^2 to take the clamping-nut member, and is also formed (inwards of or below this internal thread) with an annular shoulder a^3, that serves as a support for a copper or other soft-



metal ring or washer, which is coned and constitutes a seating for the electrode and insulator unit b, the latter being designed to be forced on to the seating and secured gas tight within the body by means of the clamping-nut c. The electrode and insulator unit b consists of a central rod or conductor b^1, which is furnished with a suitable sparking-point b^{13} at its lower or inner end, and also with a collar or enlarged part b^2, that serves as a bearing or abutment for the insulator sleeve b^4 that surrounds the rod, and is held in place thereon by a nut-and-washer arrangement, such as b^5, b^6, b^7. The lower portion of this sleeve b^4 is formed with tapered or coned enlargement or collar b^8, that provides an annular shoulder or ledge at b^{10}, this coned portion being entirely enclosed in an internally-coned metal ferrule or bush b^{11} which is permanently and rigidly secured gas-tight upon the insulation by spinning or closing its upper part b^{12} over the annular shoulder b^{10} of the sleeve. The body ferrule is cylindrical or parallel-sided, and its external diameter corresponds to the internal diameter of the chambered part of the plug-body a, wherein the member b is located, whilst its base or lower end is coned or tapered at b^{14} to correspond to the taper of the seating-ring inside the body, so that when the complete electrode and insulator unit is placed in position within the body, and the clamping-nut c is screwed home, the ferrule is clamped and confined between the nut and seating-ring, and the two coned surfaces, which are forced together by the pressure of the nut, establish a proper gas-tight joint between the removable insulator unit and the plug-body. (*Accepted October 20, 1915.*)

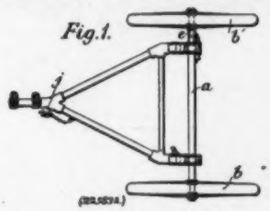
GUNS AND EXPLOSIVES.

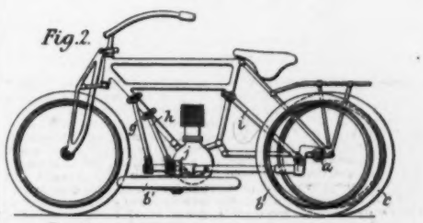
10,287/15. A. F. Petch, Westminster (*C. L. Wright, South Bethlehem, U.S.A.*). **Cartridges.** [4 *Figs.*] July 15, 1915.—This invention relates to an improved separator, adapted either to separate different kinds of explosives in a cartridge-case, or to prevent relative movement of the particles of explosive when only one kind is used. According to this invention, a separator for use in a cartridge-case comprises three sections, interlocked near their edges, and forming a structure which is triangular in cross-section. 10 indicates a cartridge-case, and 11 a projectile secured in the open end of the case in the usual manner. The present invention is used in connection with the larger sizes of cartridges, such as are used in rapid-fire guns. As usually constructed, a certain amount of explosive is placed in the closed end of the case

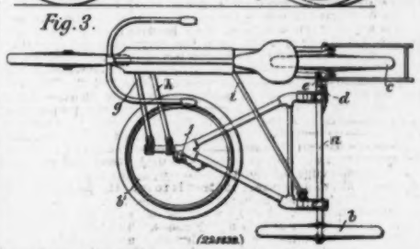


surrounding the primer, and upon this is placed a wad or diaphragm 12. The separator A extends from wad 12 to the base 13 of the projectile, and it is preferably constructed of three rectangular pieces of cardboard or equivalent material, as illustrated in Fig. 3. The section 14 has two slits 14a in one end and extending throughout half its length, the slits being at the sides of the section, and parallel with its edges. The section 15 has similar slits 15a at its other end. The sections 14 and 15 are identical in structure, but used in reverse positions when assembled. The section 16 has a slit 16a at one end extending parallel to and near one side of the section, and a similar slit 16b at the other end, and extending parallel to and near the other side. (*Accepted October 20, 1915.*)

22,583/14. W. Rankin and R. Player, Tipton. Gun-Carriages. [4 *Figs.*] November 16, 1914.—This invention has for its principal object to provide an improved arrangement of gun-carriage in conjunction with a motor-cycle whereby a gun can very conveniently be transported by means of the cycle and quickly brought into action after detachment from the cycle. The invention comprises the employment of a detachable wheel







on one end of the axle of a gun or other carriage, and the provision of means whereby the end of the axle from which the wheel has been removed can be quickly secured to one side of the cycle, the carriage being then supported partly by the other wheel on the axle and partly by the cycle. The axle a of a small gun-carriage has attached to its opposite ends a pair of wheels b, b^1, which are preferably pneumatic-tyred. One of the wheels, b^1, is made detachable, and the end of the axle from which the wheel

is removed is adapted in any convenient manner for connection to one side of the motor-cycle frame. Preferably the point of connection is as near as possible the centre of the rear road-wheel *c* of the cycle. The connection between the gun-carriage axle and the cycle is conveniently effected by means of a projection *d* on the cycle-frame, which enters a socket *e* on one end of the axle. The axle is secured against accidental detachment by a transverse cotter-pin, which enters a circumferential groove in the projection. It is obviously necessary that the gun-carriage should be clear of the ground when attached to the motor-cycle. This is preferably effected by stays *g*, *h*, and *i* connected to the carriage and to the frame of the cycle. All the stays are detachably connected at their ends by pins or screws to lugs on the members to which they are attached. The detached wheel is very conveniently carried by mounting the same on the underside of the gun-carriage. The projecting end of the detachable wheel-axle, which is similar in shape to the projection *d* above mentioned, and is similarly secured to the axle *a*, is inserted into a socket *j* on the carriage, and secured by a cotter. By arranging a gun-carriage as above described a small gun can very readily be transported by means of a motor-cycle, and when required the gun can speedily be brought into action and mounted independently of the motor-cycle, leaving the latter free for other purposes. It will be understood that the gun may be fired, if necessary, without detachment of the carriage from the cycle. (*Sealed December* 23, 1915.)

PRINTING AND ALLIED MACHINERY.

6440/15. Lanston Monotype Corporation, Limited, London. (*Lanston Monotype Machine Company, Philadelphia, U.S.A.*) **Record-Strip Composing Machines.** [3 *Figs.*] April 30, 1915.—This invention relates to keyboard-actuated machines, and refers particularly to pattern or record-strip composing or preparing-machines wherein a record strip is suitably perforated to form the controlling member of an automatic type-casting machine, although it is to be understood that the invention may be applied to, or embodied in, keyboard-machines of any type and for any desired purpose where it is desired to make use of a series of parallel bars adapted to be controlled or actuated by the keys, and to, in turn, perform functions in the operation of the machine. According to the present invention, the bars are held by guiding members furnished with spacing projections located between alternate bars to form side guides therefor, the projections themselves forming edge guides for the intermediate bars, and preferably the spacing projections at opposite edges of the bars are alternately arranged; each projection is preferably of very slightly greater thickness than the bars with which it co-operates, and the recesses between the projections are of dimensions which preferably correspond to the dimensions of the projections themselves; thus each bar will be independently supported and guided, and the space between adjacent bars may be reduced to a point which would be impracticable were side guides or spaces employed between adjacent bars. 1 is the frame of the machine, 2 the removable key-bank frame, in which are mounted a series of keys 3, usually of bell-crank lever formation, adapted when depressed to co-operate with projections 4 on one or the other of a series of key-bars 5; the key-bars, which are provided at their lower edges with projections 6 for co-operation with the upper bars or bails 7 carried by rock-shafts 8 journalled in the frame of the machine, and having other bars or bails adapted to co-operate with upwardly-extending projections 10 on the valve-bars 11. The depression of a key 3

Fig. 1.

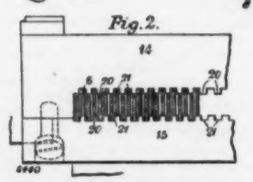


Fig. 2.

moves one of the key-bars 5 longitudinally, and the latter, through the rock-shaft and bails, moves one or a predetermined group of valve-bars forwardly to open valves 12 for operating or controlling the punching and record-strip feeding mechanism in a well-known way. The key-bars 5 and valve-bars 11 are mounted respectively in the key-board frame 2 and frame of the machine, and must, of course, be guided so as to move with freedom, and at the same time their positions must be controlled accurately in order that they may properly perform their functions. The guiding members, which in the machine illustrated are also the supporting members for the bars, are indicated at 14, 15 and 16, 17, being arranged at the front and rear of the key-board frames whereby the bars are supported at their ends and their intermediate portions left entirely free for co-operation with the controlling and operating parts of the mechanism. The guiding members 14 and 15, in accordance with the present invention, are provided with spacing projections 20 and intermediate recesses 21 (see Fig. 2). The projections and recesses are preferably made a few thousandths of an inch wider than the thickness of the bars, the proportions being considerably exaggerated in Fig. 2 in order to illustrate the invention to better advantage, and inasmuch as it is desirable to make the bars all of substantially the same width and to guide and space them at opposite edges, the projections and recesses at the opposite edges of the bars—to wit, at the top and bottom edges—are alternately arranged; that is to say, the projections 20 of one guiding member are opposite the recess 21 of the co-operating guiding member, whereby a bar at one edge is guided in a recess formed by the adjacent projections, which latter therefore constitute side guides for that edge of the bar, while at its opposite edge it is guided by the face of the projection which constitutes an edge guide, and the two adjacent bars will constitute the side guides. The arrangement illustrated, in addition to the advantages hereinbefore stated, has the advantage of preventing the sides of adjacent bars from coming together throughout an extended area, for the tipping or inclination of either of two adjacent bars will cause contact at one edge only. Thus there can be no extended frictional area which can by any possibility retard or materially interfere with the operation of a bar or cause an adjacent bar to remove therewith when it is actuated. (*Accepted October* 20, 1915.)

STEAM-ENGINES, BOILERS, EVAPORATORS, &c.

359/15. Societe Anonyme des Etablissements Delaunay-Belleville, Saint Denis, France. Steam-Generators. [2 *Figs.*] October 21, 1914.—This invention relates to improvements in water-tube steam-generators of the Belleville type, having each element formed of two intersecting spirals, and has for its object to facilitate the discharge from the purifier of water affluxions into the purifier, which may take place at certain moments. According to this invention, the tubes of the boiler are continued into the purifier in such a manner that the tube of one spiral enters the purifier above the level of the liquid in the purifier, while the other tube, which has an oblique section, just reaches the level. By this arrangement a portion of the water contained in the purifier enters the lowermost part of the oblique section of

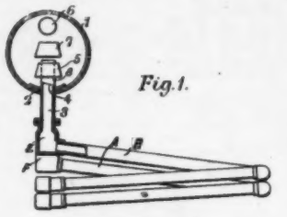


Fig. 1.

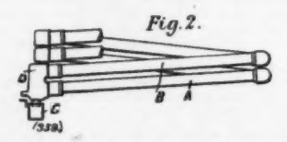


Fig. 2.

the tube of the upper spiral, and descends, facilitating thereby the discharge from the purifier when water affluxions into the purifier occur. C is the lower collector, D is the lower box, A and B are the lower and upper spirals respectively, E and F are the upper boxes connected with the purifier by means of the tubes 3 and 8. The tubes through which the steam is discharged from the elements are screwed into the purifier 1, which is reinforced by a sheet-metal plate 2. The outlets 3 of the upper spirals are cut obliquely at 4 in the purifier, from 4 cm. to 5 cm. at the rear and 1 cm. at the front, above the reinforcing member 2. This arrangement may be completed by baffle-plates 5 and 7, forming inverted bells, which prevent the water carried by the steam leaving the upper spirals being projected towards the centre of the purifier and partly carried forward towards the steam-supply pipe 6. (*Sealed December* 23, 1915.)

20,637/14. S. E. Alley and G. Woodvine, Glasgow. Water-Tube Boilers. [2 *Figs.*] April 3, 1915.—The invention relates to that type of vertical water-tube steam boiler in which there is an inner shell member having water-tubes, and forming at its lower part the firebox and an outer shell member between which and the inner shell member is a water space, there being a fuel-shoot or nozzle arranged between outer and inner shell for firing purposes, while the inner shell member is provided at its upper end with a flange-ring having an outward flange making joint with the end plate of the outer shell member which at its lower end has an interned lip or flange-ring making joint with the outward flange of a flange-ring on the inner shell member beneath it. According to this invention, the firing-shoot, flanged at its inner end in ordinary fashion for permanent attachment to the inner member, is provided at its outer end with an outward annular flange around its top part and an inward annular flange around its bottom part. By these flanges the shoot is secured to the outer member by bolts accessible, in the case of the lower flange, through the firing aperture in the outer shell, and in the case of the upper flange by way of a hand-hole in the outer shell. In order that the inner member may be withdrawn with the shoot in position, the inner

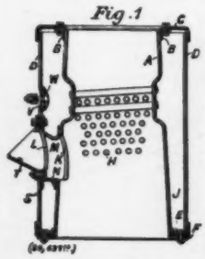


Fig. 1

Fig. 2

member is tapered, its least diameter being at the top. Flats are so formed on the inner member in position to receive the water-tubes that its section is rectangular at one part. The inner shell member A, tapered, and with its least diameter at the top, is provided at its upper end with a flange-ring B, the outward flange of which makes joint with the inner edge of an end-plate C closing the upper end of the boiler and carried by the outer shell member D. At its lower end the outer member D has on it an inturned flange E which makes joint with the outward flange of a range-ring F carried by the lower end of the inner member A. Bolts passing through the joints made by the flange-rings at the top and bottom of the boiler securely bind the inner member A and the outer member D together. The lower part of the interior of the inner member A forms the firebox, whilst the upper part carries water-tubes H communicating with the water space J between the two members A, D. Flats are so formed for the water-tubes that the section of the inner member A is rectangular at one part (as shown in the upper part of Fig. 2). To permit of the firebox being charged, apertures K, L are provided in the two members A, D, and surrounding these apertures and extending between the two members there is a shoot M. The inner end of this shoot has formed on it a flange N, by means of which it is secured to the inner member A by rivets. The outer end of the shoot M is secured to the outer member D by bolts passing through apertures in a flange S formed on that end of the shoot. These bolts R also carry on the exterior of the member D a feed-hopper T forming an extension of the shoot M. A hand-hole V closed by a cover W is provided to enable the uppermost of the bolts to be inserted. In order to remove the inner member A for cleaning or overhauling, the bolts securing the inner and outer members A, D together, and the bolts R securing the shoot M to the outer member D, are withdrawn and the inner member A lowered bodily, the internal diameter of the flange E being sufficiently large to permit of the passage through it of the inner member with the shoot attached thereto. (*Accepted October* 20, 1915.)

TEXTILE MACHINERY.

22,961/14. The Bradford Dyers' Association, Limited, and H. V. Nunn, Bradford. Stentering-Machines. [4 *Figs.*] November 24, 1914.—This invention relates to mechanism for automatically guiding cloth or fabrics in stentering or other machines, and consists in the employment of detector devices, which are automatically brought into use by the fabric departing from its upper path, to put into action a reciprocating member to separate the guiding-rollers between which the fabric passes, and devices to retain such guiding-rollers in their separated positions until a slight deviation of the fabric in the opposite direction from its normal path brings about the re-engagement of the rollers. The lower or hooked end p^3 of the detector-lever p is arranged to have an additional part, or additional hook 2, mounted upon it. This hook 2 is formed on a base-piece 2a, which will slide upon the lower end of the detector-lever p. Upon the framework m^3 (which is fixed upon the lower framework m^4) is a holding-catch 3, which is fixed upon its pivotal shaft 4, being arranged to oscillate in the bearings 4b, 4c, while a spring 5 is made to act upon so as to return the catch part 3, when free, into its normal position. Upon the same shaft 4 is fixed a horizontal arm 6, which is for engagement with the hook 2 that slides upon the lower end of the detector p, before referred to. The continuously reciprocating connecting-rod v^1 and sleeve 7 are arranged to be situated centrally beneath the gripping or guiding rollers *b* and *c*. The roller *c* is supported by bearings *m*, which have a projection 12 fixed thereon to extend downwardly (in alignment with the sleeve 7) to take through openings made in the framework m^3, so that same may be guided thereby when receding and advancing from and towards the roller *b*. The sleeve 7 has a lateral arm 7a, upon which a hook *s* is mounted, and upon which also is mounted a vertical projection 8. The hook *s* is to operate in conjunction with the hook p^3 at the end of the vertical detector p, while the projection 8 is to operate in conjunction with the hook 2, which slides vertically upon the lower end of the detector p. The detector p is pivoted at p^1 upon a bracket 10 carried by the bearings *m*, while its counter-balancing arm 11, Fig. 2, is adjusted or made of sufficient weight to always tend, when free, to cause the upper end p^4 of the detector p to move towards and press or rest upon the edge of the cloth *d* which is passing between the rollers *b* and *c*. The sliding part 12, which supports the bearings *m*, has motion transmitted to it in a vertical direction by a horizontal lever 13, which is

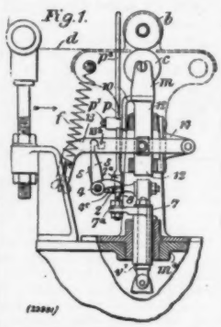


Fig. 1.

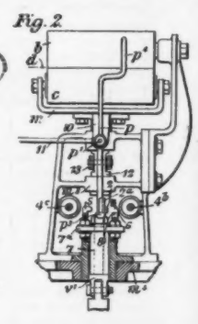


Fig. 2.

pivoted upon a bracket 14 fixed to the stationary framework m^3. The extending end of the lever 13 is bent downwardly, so that a sufficiently long retracting spring *f* may act thereon to keep the same, when free, in a normal raised position; thus the spring *f* will keep the roller *c* firmly pressed against the roller *b* unless interfered with as hereinbefore described. The reciprocating connecting-rod *v* and the sliding sleeve 7 are continuously kept in motion by eccentric mechanism, and during the time that the fabric *d* is passing between the rollers *b* and *c* in such position or order that its edge will keep the end p^4 of the detector *p* in the vertical position shown by Fig. 2, the hooks p^3 and 2 on its lower end are held clear of the reciprocating hook *s* and projection 8, and no motion is transmitted to any other part than these continuously reciprocating devices. When, however, the fabric *d* moves too far over or between the rollers *b* and *c* that it is in the direction to the right in Fig. 2, then the detector-arm p^4 is pressed or moved against the weight of this arm 11, at which time the hook p^3 will be brought beneath the reciprocating hook *s*, which will therefore pull down the detector in a vertical direction, causing it to move the sliding parts 12 and bearing *m*, and therefore separate or bring the roller *c* clear of the roller *b*. At the time that it thus moves detector *p* in this vertical direction the sliding of the part 12 will move the lever 13 against the retracting actions of the spring *f*, and so bring the projection 13b, which extends laterally from the lever 13 beneath the hook 3 (the hook part of which is shown in broken lines, Fig. 1), at which time the recoil of the spring 5 will cause the hook 3 to lay hold of the projection 13b, and retain the lever 13 against its retracting spring *f*, and therefore also retain the roller *c* clear of the roller *b*, while at the same time liberating the hook p^3 from the hook *s*. The detector pressing against the edge of the fabric will then gradually assume its normal position until the said fabric is, by the guiding devices on the opposite side of the machine (or on its opposite edge), drawn back slightly beyond its normal position on which the detector p^4 will move or follow the fabric and thereby bring the catch 2 over the top of the reciprocating projection 8 and beneath the horizontal arm 6, by which means on the rising of the said projection 8 the catch 2 will be caused to slide upon the lower arm of the detector *p* to act upon the arm 6 so as to oscillate the shaft 4 and move the catch 3 from engagement with the projection 13b on the lever 13, hence liberating same, so that by the recoil of the spring *f* the roller *c* is brought back into contact with the fabric, to press the same against the roller *b*. As similar mechanism to that above described is mounted on the other side of the fabric when the fabric moves to one side or the other, the apparatus on such side of the machine will act as above described to bring about the guidance of the said fabrics as will be understood. (*Accepted October* 20, 1915.)